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ENGINEERING:

An Illustrated Weekly Journal.

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See half-page Advertisement, page 66, Aug. 31.

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Professor W. H. BOOLES, DSc., F.R.S.
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Professor A. G. HALE, F.I.C.
The College provides practical scientific training for students who desire to become Civil, Mechanical or Electrical Engineers or Chemists.
Candidates are required to pass an Entrance Examination in Mathematics and English, but the Matriculation Certificate of any British University, and certain other qualifications, are accepted in lieu of it. The next Entrance Examination will be held on Tuesday, 18th September. Applications for admission should be forwarded to the College on forms to be obtained from the REGISTRAR. The Programme of the College may be had on application. B 47

University of Birmingham.

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Courses in Civil Engineering leading to the Degree of B.Sc. and Higher Degrees, also courses in Civic Design and Town Planning. The new Session will commence on October 1st, 1923.
Full particulars and syllabus can be obtained from Professor Lea, or from the undersigned.
GEO. H. MORLEY,
Secretary. B 579

The University of Sheffield.

SESSION 1923-24.

Vice-Chancellor: Sir HENRY HADOW, C.B.E., D Mus., LL.D.

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The Courses in the DEPARTMENT of ENGINEERING extend over three or four years and prepare students to become Mechanical, Electrical, Civil or Mining Engineers, or specialists in Fuel Technology or Glass Technology.
The Courses in the DEPARTMENT of METALLURGY cover a period of three or four years and prepare students for positions of responsibility either (1) in Iron and Steel Manufacture; or (2) in the Non-Ferrous Metallurgical Industries.
The LECTURE COURSES in all the Departments are supplemented by practical Training in Laboratories and Workshops, which are fully equipped for the purpose of advanced scientific teaching, investigation and research.
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The LECTURE COURSES commence OCTOBER 3rd, 1924.
The TECHNICAL LABORATORY COURSES commence SEPTEMBER 25th, 1923.
For further details of the Courses and for particulars of the Degrees, Associateships, Diplomas, and Certificates awarded on their successful completion, application should be made to
W. M. GIBBONS,
Registrar.
B 444

University of London.

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FACULTY OF ENGINEERING.

COMPLETE COURSES OF STUDY, extending over either three or four years, are arranged in
CIVIL, MECHANICAL and ELECTRICAL ENGINEERING
for the Engineering Degrees of the University of London, and for the Diploma and Certificate of the College.
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Professor A. H. JAMESON, M.Sc., M.Inst.C.E., Civil Engineering.
C. H. LOBBAN, B.Sc., A.M.Inst.C.E., Senior Lecturer.
Professor E. WILSON, M.Inst.C.E., M.I.E.E., (Dean), Electrical Engineering.
R. M. SHAWCROSS, A.M.Inst.C.E., M.I.E.E. Lecturer.
Professor S. A. F. WHITE, M.A., Mathematics.
Professor G. B. JEFFERY, M.A., D.Sc., ditto
Considerable Extensions have been made in the Engineering Department. These include a large additional drawing-office, lecture room, and laboratory for Hydraulics and Strength of Materials in the Civil and Mechanical Departments; and research rooms, including Wireless Telegraphy, in the Electrical Engineering Department. Large additions have been made to the equipment of the Laboratories in the three Departments for purposes of teaching and research.
There is a College Hostel and a large Athletic Ground.
For full information apply to the SECRETARY, King's College, Strand, W.C. 2. B 105

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DAY COURSES.

FULL-TIME (DAY) COURSES extending over three or four years, and leading to the Diploma of the College, are arranged in the following Departments:—
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ELECTRICAL ENGINEERING.
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These Courses are designed to meet the needs of Students wishing to present themselves for the Degree Examinations of the London University.
Special Facilities are available for Advanced Study and Research.
Further particulars and prospectuses may be obtained on application to the PRINCIPAL, Technical College, Bradford. B 594

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Lecturer: ARTHUR H. BARKER, B.A., B.Sc.

A complete Three-Year Course, leading to the Diploma in Heating and Ventilating Engineering, also Special Courses of Instruction for Architects and for those intending to specialise in the practice of Heating and Ventilation, are provided.
The Session will begin on Monday, October 1st.
On Wednesday, October 10th, at 7 p.m., Mr. Barker will deliver a Public Lecture on "The Equipment of a small House."
Particulars, including Syllabus of Lectures, may be obtained on application to the undersigned:—
WALTER W. SETON,
Secretary,
University College, London,
Gower Street, W.C.1. B 578

Borough Polytechnic

INSTITUTE,
Borough Road, London, S.E. 1.

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Under the direction of GEO. E. DRAYCOTT, Wh. Ex., A.M.I.M.E.

REINFORCED CONCRETE DESIGN
(Lectures and Drawing Office Work).
By STANLEY VAUGHAN, B.Sc. (Hons. Eng.), A.M.I.C.E. Thursday, 7.15 to 9.45 p.m.
Commencing on September 28th, 1923.
Note:—This forms part of the Fifth Year's work of the Recognised Course in Structural Engineering for the National Certificate, but qualified non-course students may be admitted upon application to the Head of the Department or to
J. W. BISPHAM, O.B.E., M.A., B.Sc.
(Principal.) B 383

Battersea Polytechnic,

London, S.W. 11.
Principal: ROBERT H. PICKARD, D.Sc., F.R.S.
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Evening Classes Suitable for Final B.Sc. (Eng.), A.M.I.C.E., A.M.I.M.E., etc., are held in the following subjects:—
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Students enrolled from September 18th.
DAY TECHNICAL COLLEGE.
Full Time Courses in MECHANICAL, CIVIL, and ELECTRICAL ENGINEERING for B.Sc. (Eng.) Degree, (UNIVERSITY OF LONDON) or COLLEGE DIPLOMA commence September 24th. ENTRANCE EXAMINATION commences September 18th. Fee: £18 per session. A higher fee will be charged to students not residing in London.
Full Particulars of all classes on application to the PRINCIPAL. B 513

ENGINEERING AND TECHNICAL OPTICS.

Northampton Polytechnic

INSTITUTE, St. John Street, London, E.C.1.
ENGINEERING DAY COLLEGE.
Full-time Day Courses in the Theory and Practice of Civil, Mechanical, and Electrical Engineering. The Courses in Civil and Mechanical Engineering include specialisation in Automobile and AERONAUTICAL Engineering, and those in Electrical Engineering include specialisation in RADIO-TELEGRAPHY.
A SPECIAL ENTRANCE EXAMINATION is held at the end of September before the commencement of each Session. The Courses include periods spent in commercial workshops and extend over four years. They also prepare for the Degree of B.Sc. in Engineering at the University of London. Fees £18 or £13 per annum.
THREE ENTRANCE SCHOLARSHIPS of the value of £62 each for the complete course will be offered for competition at the annual entrance examination in September.
OPTICAL ENGINEERING AND TECHNICAL OPTICS.
Full and Part-time Courses in this important department of Applied Science are given in specially equipped laboratories and lecture rooms. The annual entrance examination is held at the end of September.
EVENING TECHNICAL COURSES
in all branches of Mechanical and Electrical Engineering commences on Monday, September 24th 1923.

The Laboratories, both Mechanical and Electrical, are well equipped with modern apparatus which, on the Mechanical side, provides for specialisation in Automobile and Aeronautical Engineering and, on the Electrical side, for specialisation in Alternate and Continuous Current Work, in Radio-Telegraphy and Telephony, and in Electrical Testing.
More complete particulars, together with conditions of entrance, etc., and all information respecting the work of the Institute can be obtained at the Institute, or on application to—
R. MULLINEUX WALMSLEY, D.Sc.
Principal.
B 511

LONDON COUNTY COUNCIL.

Westminster Technical

INSTITUTE.
Vicent Square, S.W.1.
Principal: J. STUART KER, B.Sc., A.M.Inst.C.E.

Session 1923-4.

CIVIL ENGINEERING.
Evening Sessional Courses to give systematic instruction to Civil Engineers in STRUCTURAL ENGINEERING, REINFORCED CONCRETE DESIGN, SURVEYING AND LEVELLING, HYDRAULICS, SPECIFICATIONS, QUANTITIES AND ESTIMATES, ENGINEERING MATHEMATICS, ETC., will begin on 24th September, 1923. Students should enrol during the preceding week.
In addition, SPECIAL ADVANCED SESSIONAL COURSES intended for those well grounded in the principles of STRUCTURAL DESIGN have been arranged as under:—
STRUCTURAL ENGINEERING (HIGHER STRUCTURES),
DESIGN OF STEEL FRAME BUILDINGS,
REINFORCED CONCRETE DESIGN.
Full particulars of the courses, fees, etc., are given in the Prospectus, which may be obtained on application to the Principal at the Institute.
JAMES BIRD,
Clerk to the London County Council.
B 576

The Sir John Cass Technical

INSTITUTE.
JEWRY STREET, ALDGATE, E.C. 3.

DEPARTMENT OF METALLURGY.

Head of Department:—
GEO. PATCHIN, A.R.S.M., M.I.M.M.

COURSES OF INSTRUCTION ON METALLURGY FOR ENGINEERS.
The following Evening Courses meet the requirements of those engaged in the Engineering Industry:—
Metallurgy of the Non-Ferrous Metals and Iron and Steel.
Metallography and Pyrometry.
Mechanical Testing of Metals and Alloys.
Heat Treatment of Metals and Alloys.
Foundry Practice.
Analysis of Engineering Works Material.

SESSION commences
THURSDAY, SEPTEMBER 20th, 1923.
ENROLMENT—Monday, Tuesday and Wednesday, September 17th, 18th and 19th, between 6 and 8.30 p.m.
Detailed Syllabus of the Courses may be had upon application at the Office of the Institute, or by letter to the PRINCIPAL. B 577

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295

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NORTH WILFORD POWER STATION.
CONTRACT No. 5.

The ELECTRICITY COMMITTEE is prepared to receive

Tenders for the Erection of

BUILDINGS in connection with the NORTH WILFORD POWER STATION.
Drawings may be seen, and copies of the General Conditions of Contract, Specification, Bill of Quantities, and Form of Tender, etc., may be obtained on application to Mr. T. WALLIS GORDON, City Engineer and Surveyor, Guildhall, Nottingham, on payment of Two Pounds, which will not be returned.
Sealed Tenders are to be delivered in the official envelope provided, to the undersigned, not later than Nine a.m., on Friday, the 5th October, 1923.
The lowest or any Tender will not necessarily be accepted, and the Committee reserve to themselves the right of dividing the work in any way they may think fit, and Tenders will only be accepted from firms who conform to the conditions of the contract as regards paying the local standard rate of wages, etc., and to the working rules of the Nottingham district.
By Order,
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham,
8th September, 1923. B 602

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, REQUIRES:—
1. DOG SPIKES,
2. STEAM HAMMER.
Tenders due on the 5th October, 1923.
Tender forms obtainable from above. B 609

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C. 2, invite

Tenders for 40-Ton Bogie

SELF-DISCHARGING BALLAST WAGONS; fee £1.
Tenders due by Eleven a.m., on Tuesday, the 9th October, 1923.
Tender forms obtainable at above address. B 610

COUNTY OF LONDON.

The London County Council invites

Tenders for the Demolition

and REMOVAL of STEEL and BRICK LINED CHIMNEY STACK, which may be inspected at the London United Electric Tramways Power Station, 74, High Road, Chiswick, between the hours of Ten a.m. and Four p.m. on any week-day, except Saturdays, from 17th September, to 1st October, 1923, both dates inclusive, by appointment with a representative of the London County Council.
Particulars and form of Tender may be obtained from the General Manager, London County Council Tramways, Victoria Embankment, W.C. 2.
No Tender will be considered if received by the Clerk of Council at the County Hall, Westminster Bridge, S.W. 1, after Twelve Noon, on Tuesday, 2nd October, 1923.
The Council does not bind itself to accept the highest or any Tender.
JAMES BIRD,
Clerk to the London County Council. B 614

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C. 2, invite

Tenders for:—

GIBS and COTTERS,
STEEL RAILS and FISHPLATES,
CAST IRON CHAIRS,
POINTS and CROSSINGS, etc.,
STEEL FISHBOLTS, and CHAIRBOLTS, etc.
SHEFFIELD TOOLS,
AXLEBOXES,
SPARE PARTS of Carriages and Wagons.
Tenders due by Eleven a.m. on Tuesday, the 25th September, 1923.
Tender forms obtainable at above address. B 623

AIR WASHING MACHINES.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders Before Eleven

a.m. on Tuesday, 2nd October, 1923, for the SUPPLY and INSTALLATION of TWO AIR WASHING MACHINES, with Pumps, Motors, etc., at the Imperial College of Science, South Kensington.
Drawings, Specification, Form of Contract, Schedules, and Forms of Tender may be obtained from the Contracts Branch, H.M. Office of Works, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to the SECRETARY, H.M. Office of Works). The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. B 610

THE METROPOLITAN ASYLUMS BOARD invite

Tenders for the Supply and

DELIVERY of TWO NEW FOUL LINEN WASHING and DISINFECTING MACHINES to Tooting Bec Mental Hospital, Tooting Bec Road, Tooting, S.W. 17, in accordance with specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The specification and form of tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Saturday, 15th Sept., 1923, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* tender sent in accordance with the instructions on the Form of Tender and after the specification has been returned.
Tenders, addressed as noted on the form, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, 10th October, 1923.
(By Order),
G. A. POWELL,
Clerk to the Board. B 599

Tenders Will be Received

at the Office of the Colonial Secretary in Singapore, S.S., on or before the 30th November, 1923, due allowance being made for delays on the Post,
For the following works:—
NEW GENERAL POST OFFICE, SINGAPORE.
Any person applying for a form of Tender must deposit the sum of £10 with THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1.
Drawings, Specifications, Quantities and Contract Documents may be seen and Forms of Tender obtained, at the Office of the Crown Agents between the hours of Ten a.m. and Four p.m.
Tenders must be addressed to the Colonial Secretary, Straits Settlements, Singapore, to reach him by 30th November, 1923. The successful Tenderer must undertake to find if required, security to the amount of $100,000 (Straits) which will be returned when the reserve deducted from certificates amounts to a like sum.
Tenders must be marked "Tender for New General Post Offices, Singapore," and must be on the printed form issued by the Crown Agents.
In the event of any person whose Tender has been accepted failing within thirty days from the date of acceptance to enter into the necessary contract or deposit the security required under the Contract for its due fulfilment, the sum deposited may be forfeited to the Crown.
Tenders sent to Singapore from overseas must be accompanied by the priced Schedule of Quantities, forwarded to the Colonial Secretary, Singapore, S.S.; in separate sealed packets marked with the name and address of the Tenderer. The priced Schedule of Quantities of the successful Tenderer only will be opened for examination, in all other cases the Schedules will be returned unopened.
The Government does not bind itself to accept the lowest or any Tender. B 593

RECIPROCAL LOAD DEFLECTION RELATIONSHIPS FOR STRUCTURES.

By C. E. LARARD, Wh.Exh., M.Inst.C.E., M.Inst.Mech.E.

(*Concluded from page* 288.)

CONSIDER next a simple problem on the second reciprocal relationship (II) by taking first the case of a girder fixed at one end with a load Q at the end B and a second load P at A, of such magnitude that $y_A = 0$ (see Fig. 8):

If P acts alone, slope at A $= \frac{P l^2}{2 E I}$

Deflection at A $= \frac{P l^3}{3 E I}$

Slope at B $= \frac{P l^2}{2 E I}$ and

Deflection at B $= \frac{P l^3}{3 E I} + \frac{P l^2}{2 E I}(L - l)$

$= \frac{P l^2}{6 E I}(3 L - l)$

Fig.8.

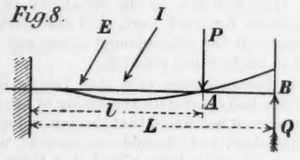


Fig.9.

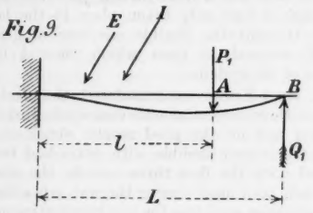
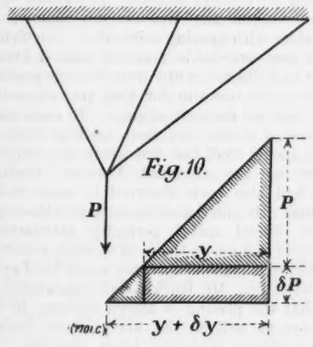


Fig.10.



If Q acts alone, $M_x = Q(L - x)$

and $\frac{dy}{dx}$ at $x = -\frac{Q}{E I}\left(L x - \frac{x^2}{2}\right)$ and $y_x = \frac{Q}{E I}\left(\frac{L x^2}{2} - \frac{x^3}{6}\right)$

Slope at A $= -\frac{Q}{E I}\left(L l - \frac{l^2}{2}\right)$ and $y_A = \frac{Q l^2}{6 E I}(3 L - l)$

$y_B = \frac{Q L^3}{3 E I}$

for P and Q acting together we have

Deflection at A $= 0 = \frac{P l^3}{3 E I} - \frac{Q l^2}{6 E I}(3 L - l)$

$\therefore Q = \frac{2 P l}{3 L - l}$

Deflection at B $= \frac{Q L^3}{3 E I} - \frac{P l^2}{6 E I}(3 L - l)$

$= \frac{P l}{3 E I}\left\{\frac{4 L^3 - l(3 L - l)^2}{2(3 L - l)}\right\}$. (9)

Now let Q_1 act at B preventing deflection at that point, while P_1 acts at A in the opposite direction (see Fig. 9):

Then P_1 acting alone produces

Slope at A $= \frac{P_1 l^2}{2 E I}$

Deflection at A $= \frac{P_1 l^3}{3 E I}$

Deflection at B $= \frac{P_1 l^3}{3 E I} + \frac{P_1 l^2}{2 E I}(L - l) = \frac{P_1 l^2}{6 E I}(3 L - l)$

Q_1 acting alone produces:

Deflection at A $= \frac{Q_1 l^2}{6 E I}(3 L - l)$

Deflection at B $= \frac{Q_1 l^3}{3 E I}$

P_1 and Q_1 acting together produce:

Deflection at B $= 0 = \frac{Q_1 L^3}{2 E I} - \frac{P_1 l^2}{6 E I}(3 L - l)$

$\therefore P_1 = \frac{2 Q_1 L^3}{l^2(3 L - l)}$

Deflection at A $= \frac{P_1 l^3}{3 E I} - \frac{Q_1 l^2}{6 E I}(3 L - l)$

$= \frac{Q_1 l}{3 E I}\left[\frac{4 L^3 - l(3 L - l)^2}{2(3 L - l)}\right]$. (10)

Comparing (9) and (10) it will be seen if the deflections are to be equal that Q_1 must equal P, thus verifying the second reciprocal relationship.

A simple exercise will illustrate the value of the third reciprocal relationship, which is also consistent with the ordinary theory of flexure.

A cantilever girder fixed at one end and loaded at the other is found to be dangerously weak, and in order to reduce the maximum stress in the material it is proposed to insert a column under the middle of the cantilever, reducing the deflection at the end to zero. Find the pressure which the column would support as a preliminary to determining the section of the column.

Referring to Fig. 9 (inverted) and using the relationship (III) given, we have

$\frac{P_1}{Q_1} = \frac{y_B}{y_A}$ $\therefore P_1 = Q_1 \frac{y_B}{y_A}$

Fig.11.

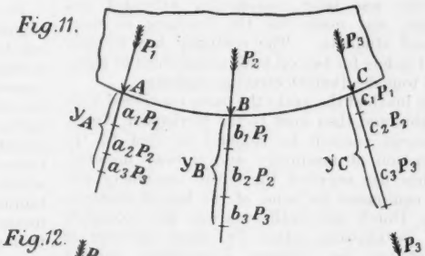
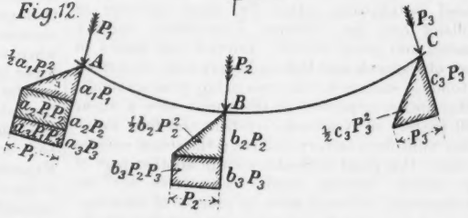


Fig.12.



$U = \frac{1}{2} a_1 P_1^2 + \frac{1}{2} b_2 P_2^2 + \frac{1}{2} c_3 P_3^2 + a_2 P_1 P_2 + b_3 P_2 P_3 + a_3 P_1 P_3$

(7701 D) (7701 C)

Now

$y_B = \frac{1}{3}\frac{Q L^3}{E I}$ and $y_A = \frac{Q l^2}{6 E I}(3 L - l)$

$\therefore P_1 = \frac{2 L^3}{l^2(3 L - l)} Q_1$

This contribution would be incomplete without making certain additional deductions which can be made from equations of the form given by (3) and (4). Re-stating these equations for U, which have the same value in virtue of the reciprocal relationship or equality between the coefficients a_2 and b_1, we have

$U = \frac{1}{2} a_1 P_1^2 + \frac{1}{2} b_2 P_2^2 + \left.\begin{matrix} a_2 \\ \text{or} \\ b_1 \end{matrix}\right\} \times P_1 P_2$. (3) or (4)

neglecting the gravity term. That is to say, if loads of P_1 and P_2 are applied at two points, A and B respectively, in an elastic structure producing displacements $a_1 P_1 + a_2 P_2 = y_A$ at A, and displacements $b_1 P_1 + b_2 P_2 = y_B$ at B, the equation (3) or (4) gives the work of deformation of the structure.

Taking the partial differential coefficient of both sides with respect to P_1 we have

$\frac{\partial U}{\partial P_1} = a_1 P_1 + a_2 P_2 = y_A$

i.e., the partial differential coefficient of the work done on the structure taken with respect to P_1 is equal to the displacement at A, where P_1 is applied.

Similarly differentiating with respect to P_2:

$\frac{\partial U}{\partial P_2} = b_2 P_2 + b_1 P_1 = y_B$

that is, the displacement at B is found by taking the partial differential coefficient of the work done with respect to the force P_2 acting at B.

These results furnish, therefore, additional simple proofs of the well-known Castigliano theorem in the case of two loads.

If $P_2 = 0$ then $\frac{d U}{d P} = a_1 P_1 = y_A$

or directly from Fig. 10 for one load:

$\delta U = y\ \delta P + \frac{1}{2}\delta y \,.\, \delta P$

$\therefore \frac{d U}{d P} = y$

giving the deflection at the joint or at the point of application of the load.

The same method of demonstration will apply for any number of loads $P_1, P_2, P_3 \ldots P_n$.

Thus, if three loads P_1, P_2, P_3, are considered we can form six equations by applying the loads in the orders shown in the first column of the table No. II. Table No. I gives the effect of each load at each of the three points of application, as well as the total deflection at each point due to the combined loads.

Figs. 11 and 12 represent the derivation of the equation at the top of Table II., when the loads are applied in the order P_1, P_2, P_3, and the other equations given for the different orders of loading are obtained in a similar way.

TABLE I.

Due to	Deflection at A.	Deflection at B.	Deflection at C.
P_1 at A	$a_1 P_1$	$b_1 P_1$	$C_1 P_1$
P_2 at B	$a_2 P_2$	$b_2 P_2$	$C_2 P_2$
P_3 at C	$a_3 P_3$	$b_3 P_3$	$C_3 P_3$
Total deflection due to all loads	$a_1 P_1 + a_2 P_2 + a_3 P_3$	$b_1 P_1 + b_2 P_2 + b_3 P_3$	$C_1 P_1 + C_2 P_2 + C_3 P_3$

Comparing the six equations in Table II, it will be seen that

Equations (1) and (2) that $b_3 = c_2$

Equations (3) and (4) that $a_3 = c_1$

Equations (5) and (6) that $a_2 = b_1$

$\therefore U = \frac{1}{2} a_1 P_1^2 + \frac{1}{2} b_2 P_2^2 + \frac{1}{2} C_3 P_3^2 + a_2 P_1 P_2 + a_3 P_1 P_3 + b_3 P_2 P_3$,

and

$\frac{\partial U}{\partial P_1} = a_1 P_1 + a_2 P_2 + a_3 P_3 = y_A$,

and since

$U = \frac{1}{2} a_1 P_1^2 + \frac{1}{2} b_2 P_2^2 + \frac{1}{2} c_3 P_3^2 + b_1 P_1 P_2 + b_3 P_2 P_3 + a_3 P_1 P_3$

$\therefore \frac{\partial U}{\partial P_2} = b_2 P_2 + b_1 P_1 + b_3 P_3 = y_B$

Similarly

$\frac{\partial U}{\partial P_3} = c_1 P_1 + c_2 P_2 + c_3 P_3 = y_C$

If there are n loads

$\frac{\partial U}{\partial P_1} = a_1 P_1 + a_2 P_2 + \ldots + a_n P_n = y_A$ and so on

for the deflection at each of the other points of application. So far the value of U has been considered as the external work of deformation of the structure due to the external forces or loads, but actually this work is also equal to the elastic resilience of the structure or the total energy stored up in the different members after straining whatever the nature of the straining action—tension, compression, bending, shear, &c.

TABLE II.

	Order of Loading.	U	U = Work done = sum of terms in each horizontal line below.					
1	$P_1 P_2 P_3$	U	$\frac{1}{2}a_1P_1^2$	$\frac{1}{2}b_2P_2^2$	$\frac{1}{2}c_3P_3^2$	$a_2P_1P_2$	$b_3P_2P_3$	$a_3P_1P_3$
2	$P_1 P_3 P_2$	U	$\frac{1}{2}a_1P_1^2$	$\frac{1}{2}b_2P_2^2$	$\frac{1}{2}c_3P_3^2$	$a_2P_1P_2$	$c_2P_2P_3$	$a_3P_1P_3$
3	$P_2 P_1 P_3$	U	$\frac{1}{2}a_1P_1^2$	$\frac{1}{2}b_2P_2^2$	$\frac{1}{2}c_3P_3^2$	$b_1P_1P_2$	$b_3P_2P_3$	$a_3P_1P_3$
4	$P_2 P_3 P_1$	U	$\frac{1}{2}a_1P_1^2$	$\frac{1}{2}b_2P_2^2$	$\frac{1}{2}c_3P_3^2$	$b_1P_1P_2$	$b_3P_2P_3$	$c_1P_1P_3$
5	$P_3 P_1 P_2$	U	$\frac{1}{2}a_1P_1^2$	$\frac{1}{2}b_2P_2^2$	$\frac{1}{2}c_3P_3^2$	$a_2P_1P_2$	$c_2P_2P_3$	$c_1P_1P_3$
6	$P_3 P_2 P_1$	U	$\frac{1}{2}a_1P_1^2$	$\frac{1}{2}b_2P_2^2$	$\frac{1}{2}c_3P_3^2$	$b_1P_1P_2$	$c_2P_2P_3$	$c_1P_1P_3$

Consequently U will in practice be expressed in terms of the strain energy of the different members of the structure, and the result differentiated with respect to any load whose displacement is required.

It is shown in the higher text books on materials

that the work done in straining an element of length $d x$, of a rod or section is given by

$$\frac{T^2}{2EA} dx \text{ for direct stress,}$$

where T denotes the direct stress—tension or compression—and A the area of the section.

$$\frac{F^2}{2GA} dx \text{ for shear stress,}$$

where F denotes the shear force.

$$\frac{M^2}{2EI} dx \text{ for bending,}$$

M denoting the bending moment and I the second moment of the section.

And consequently the work accumulated in any length L for a particular member is given by the integral of the above between the limits 0 and L—T, F and M being expressed in terms of the external forces and the configuration, so that the practical solution for deflection at any load P will be expressed by

$$\frac{\partial U}{\partial P} = \Sigma \frac{\partial}{\partial P} \int \frac{T^2}{2EA} dx + \Sigma \frac{\partial}{\partial P} \int \frac{F^2}{2GA} dx + \Sigma \frac{\partial}{\partial P} \int \frac{M^2}{2EI} dx = y_{p_1}$$

each integral being taken between the proper limits.

Now as T, F or M are expressed in terms of the external loads and configuration they are as often as not binomial, trinomial or multinomial expressions, and to perform the operation of squaring before integration would be very tedious.

Since, however, the expressions have to be differentiated as well as integrated the work is considerably shortened by placing the symbolic operator $\frac{\partial}{\partial P}$ on the right of the integration sign, thus differentiating first and integrating afterwards giving

$$\frac{\partial U}{\partial P} = \Sigma \frac{1}{EA} \int T \cdot \frac{\partial T}{\partial P} dx + \Sigma \frac{1}{GA} \int F \frac{\partial F}{\partial P} dx + \Sigma \frac{1}{EI} \int M \frac{d M}{\partial P} dx$$

If the area A of the section and the value of I vary, then each would be expressed in terms of the variable and placed on the other side of the integration sign.

The application of these results, using the numerical data of practical design instead of algebraic symbols, then becomes exceedingly simple, even for structures which are often regarded as requiring advanced mathematical treatment.

THE INSTITUTION OF NAVAL ARCHITECTS IN HOLLAND.

(*Concluded from page* 308.)

VISIT TO "DE SCHELDE" WORKS.

THE Schelde Shipbuilding and Engineering Company, Limited, the well-known company who have constructed all the vessels for the Rotterdam Lloyd Line since 1883, opened their works on Monday afternoon to the inspection of the party, Dr. Jan Smit, Mr. H. C. Wesseling and other members of the organisation conducted the members through the works where turbines are made under licence from the Parsons Company, and Diesel engines of the Sulzer type are built. The two building berths are of reinforced concrete, and are 600 ft. in length. The work in progress includes a 30-knot protected cruiser for the Dutch Navy and two mail steamers for the Rotterdam-Lloyd.

After the visit, the party proceeded by train to Scheveningen.

VISITS TO WORKS IN AMSTERDAM.

On Tuesday morning, September 4, the members travelled to Amsterdam to see some of the engineering works and shipyards. The first visit was made to the yard of the Amsterdam Drydock Company. Inspection was made of ships under repair in the five floating dry docks, the largest of which was recently completed by the Netherland Shipbuilding Company and has a capacity of 25,000 tons. The length is 650 ft., while the breadth and depth are 130 ft. and 26 ft. respectively. Among the features of interest at these works are the installation of oxygen-making plant and two floating cranes of 25 tons and 75 tons lifting capacity respectively.

In the Netherland Dock Company's yard, which was visited next, there are three graving docks, the first of which is 640 ft. long while the other two, which are side by side, with a common crane of 14 tons capacity, between them, as well as a simple traveller of 3¼ tons size on the other side of each, are 515 ft. and 437 ft. in length respectively. All three have electrically-operated steel gates controlled from the pump house. A half-portal crane with a span of 135 ft. travels over the large storage area for all rough and unfinished materials. The Netherland Shipbuilding Company has built up a successful business in the construction of floating docks, oil tankers, and oil and cargo steamers. The older yard is situated behind a lock and bridges of about 60 ft. width which prevented the development of business in connection with very large vessels. The brothers Goedkoop, realising this limitation, designed a new yard with seven berths on the North Sea Canal which is capable of use in building vessels up to 1,000 ft. length. Three of the berths are now ready. The slips have concrete floors resting on piles, and two of them may be combined for building floating docks. Gantries 87 ft. high extend on each side of the building berths and carry electric cranes each with a lifting capacity of 3½ tons.

In the works a multiple drilling machine and three single-operator punching machines excited interest, and were the subjects of discussion in regard to rates of working. The directors erected in 1897 a school within the works for the training of apprentices. Its scope was later considerably extended and provision was made for the teaching of more advanced students. The company has recently booked orders for two oil tank motor ships of about 13,000 tons deadweight carrying capacity.

After lunch at the works the party continued their inspection and then went to the Werkspoor Works, the largest concern in Holland devoted to the construction of machinery and railway material. The firm has supplied the entire machinery and boiler equipment for some of the largest steamers of the Dutch mercantile marine, also complete Diesel installations, plant for sugar factories in Holland and her colonies, locomotives, railway coaches and goods trucks. Interest was shown in a set of Babcock and Wilcox boilers with Underfeed automatic stokers for the steamship Swartenhondt. Other items inspected in the shops were a sugar mill battery of Krajewski crushers and four three-roller mills for a factory in Java; the steam engines to drive this plant were also seen in another part of the works. Several goods locomotives for the Netherlands Railways were in process of construction. A quadruple expansion marine engine, turbines of the Parsons type and the gears and cases for a cargo steamer afforded interest to the visitors.

ROYAL CONGRATULATIONS.

The second meeting for the reading of papers was held in the Kurhaus Hotel, Scheveningen, on Wednesday, September 5. The Duke of Northumberland presided, and opened the proceedings by reading a telegram from the Secretary to Her Majesty the Queen of Holland thanking the members of the Institution for their telegram of congratulations. After a few introductory remarks emphasising the growth of indebtedness of the Institution to the Dutch hosts, the chairman asked Mr. Francis Henderson to address the meeting. In the short speech that he delivered, he spoke of the similar characteristics of the British and Dutch peoples, the ventures that they had engaged in at sea, and their building up of empires beyond the sea. The Little Holland of England was undertaken at its inception by Dutch engineers.

STEAM TURBINES IN HOLLAND.

A paper on "Steam Turbines for Marine Propulsion in Holland" was read by Professor D. Dresden, of The Hague. A reprint of this paper will be found on page 344 of this issue.

Sir Thomas Bell opened the discussion and expressed the thanks of the members for the valuable analysis of Dutch experiences. He agreed with the author when he said "that more is to be gained by introducing a flexible element in the gearing than by trying to turn the whole system into a nodal arrangement, where the entire gear is kept rigid." It was to be imagined that the references to single-reduction gearing being obsolete applied only to low-powered cargo vessels, for some engineers were finding that the single reduction system was preferable to the double for steamers of 12 knots and upwards, in which over 3,000 s.h.p. was transmitted to each propeller. The weight and cost of the larger turbines in the single-reduction case was fully compensated for by the reductions on the same items for the case and gearing, with the lubricating pipes and attachments. In addition the improved mechanical efficiency of the single-reduction gear over that of the rival scheme must be considered as well as the slightly lower resistance to rotation found in the slower-running high-pressure turbine. It was pleasing to hear that the Dutch steamship owners and officials held favourable opinions of geared turbines, which were also emphasised by Professor Dresden. That was due to the capability of the Dutch engineers, for much care, skill and patience were necessary in the development along any line of progress in engineering progress.

Mr. J. A. Lambrechtsen said that two or three weeks ago they had opened up the casing of the gear of the Ares, when it was found that the first-reduction gear was polished, but showed no signs of wear, while the second was a little pitted, but there was evidence that it had only taken place in the last year. He thought the flexible coupling of great value and referred to tests which showed the importance of the system.

Mr. H. Ruck-Keene congratulated the Dutch engineers on their successful achievements in turbine construction and on the good results obtained in working. Their only trouble with gears had been experienced with the first three vessels, the gears for which had been made during the war, when they had not the proper machines for accurate cutting and adjusting the pinions of the gears. It was not to be taken, however, that that was the only source from which troubles with gearing originated. Inefficient lubrication and unreliable material caused breakdowns, but that did not in any way alter the position that gears would not run for long periods unless accurately cut and properly aligned. In some cases when saturated steam was used, blading made of 5 per cent. nickel steel had not given as complete satisfaction as the standard Parsons' blading. Corrosion had also been observed in some nickel steel blading. He noted that the author of the paper had found Monel metal perfectly satisfactory. Expressions of opinion on the most suitable materials to use in different types of turbines would be of great interest and value. Mr. Ruck-Keene commented on the fact that the placing of astern turbines in the high-pressure as well as the low-pressure casings was in accordance with the latest practice. He was pleased to note that Professor Dresden called attention to the necessity, from the standpoint of upkeep and overhauling, of designing the turbines so that the casings could be easily lifted for examination. The engineer-in-charge might think twice before opening up if he had to dismantle several other parts of the machinery. Frequent examination might lead to the arrest of some trouble at its start.

Mr. R. J. Walker stated that the author had given a very interesting account of the geared turbine installations that had been constructed in Holland. To use gearing in 1915 as was done in the Rotterdam-Lloyd vessel Turbinia, indicated the confidence of Dutch engineers and was effective testimony to their enterprise and courage. The practice of the Parsons' Company for marine turbines had been to use non-ferrous blading with the object of avoiding the possibility of corrosion. For saturated steam below a temperature of 400 deg. F. the metal used was 70–30 brass, in place of which an alloy of copper and manganese was employed for superheated steam, and wherever the temperatures were over 400 deg. F. The common practice was to have 200 deg. of superheat.

In Britain, astern turbines were fitted in both the high-pressure and low-pressure units for single-screw installations, but in twin-screw cases it was considered sufficient to have astern blading in each low pressure case only, and by this arrangement the

necessity of fitting a diaphragm in the high pressure was avoided. When two pinions were driving the same wheel, there was no doubt that shocks and excessive stresses could be reduced by the introduction of flexibility, but there were over 500 merchant ships, representing over 2,500,000 h.p., where similar provision for flexibility had not been made. The elimination of the additional device to ensure flexibility was merely a question of reasonable accuracy in the cutting of the teeth, and most marine engineers preferred that solution. The comparisons of reciprocating engines with steam turbines, given in the paper, showed variation between an advantage of 25 per cent. in favour of the turbine to the discreditable position of inferiority. In those cases where the reciprocating engine proved the better the reason was commonly not difficult to find, and was probably due to wasteful auxiliaries. Careful tests would serve in the determination of the exact location of the trouble. When a proper comparison was made there was no reason why the savings stated should not be obtained in every case.

In reply to the discussion, Professor Dresden summed up the flexible drive question in favour of its introduction, and cited a case of German experience where the introduction of flexibility ended a bad case and made possible the running free from noise. The word obsolete he agreed was too strong to use in connection with single-reduction gearing, but for the types of ships built in Holland it certainly was not the best solution. He was glad that Mr. Ruck-Keene had strongly advocated construction permitting easy dismantling. Monel metal proved to be very useful for blade construction. On the Ares they had not got the most recent designs of auxiliaries, but had thought it better to have the one change, the poorer unit, and make use of auxiliaries, to the working of which the men were accustomed and which were available. The economy shown for the turbines in the example given in the paper would be more striking if the auxiliaries had been of the recently-introduced types.

The Duke of Northumberland congratulated Professor Dresden on the valuable paper he had presented, and for the information it conveyed of the views of the Dutch engineers on modern turbine questions. After moving a vote of thanks to the author, His Grace asked Sir Archibald Denny to take the chair for the remainder of the meeting, as he had to leave to fulfil other engagements.

Mechanical Stokers for Marine Boilers.

Mr. W. J. Muller then read his paper on "A Few Results from Practical Experience with Mechanical Stokers applied to Marine Water-Tube Boilers." This paper we reprinted in full on page 297 of last week's issue.

Sir John E. Thornycroft expressed the thanks of the members, and opened the discussion by suggesting that as mechanical stokers necessitated the use of fuel of a fairly uniform size it was advisable to take courage and use pulverized coal. To obtain the coal in suitable form for use with stokers necessitated the use of crushers. If plant of that type was installed the breaking up might be extended until the coal was in a powdered state. The added advantages due to pulverisation would be quite considerable. Tests had been conducted on shore which showed that control was possible to an extent comparable with that in the case of liquid fuel.

Mr. J. A. Lambrechtsen thought that the tests showed a step forward in fuel-burning at sea. The question of how many furnaces could be fired by one man was not of great importance in Holland as they commonly fired three or four, and in exceptional circumstances even more. As the gaps between the fire-bars were very small he thought the bars were not made of cast-iron and asked information about their nature. Large clinkers might be produced and, indeed, of such sizes as would not go through the small doors, provided for the purpose, in the construction. Steamers had sometimes only one boiler and, as shut downs due to bad joints at manholes were possible, he thought it opportune to suggest that two were necessary.

Professor Dalby called attention to the value of the trial results given in the paper, and raised the question of separating the furnace efficiency from that of the heat transmission. The deduction of the two component efficiencies gave a great amount of information of use in detecting the faults in a boiler. If that separation were carried out the efficiency of any stoking appliance could be most clearly demonstrated. He asked what reduction in the number of boiler-room workers could be effected with these stokers. There seemed to be no reason why crushing should not be continued until pulverised coal was obtained. Successful tests had been conducted with fuels which could not be used in any other way, and a reduction in the personnel employed was possible.

Mr. W. J. Muller in reply to the discussion, said he had studied the possibilities of pulverised coal, but found that the system had some drawbacks. It was not only necessary to crush the coal but also to dry it, and it was practically impossible to fit driers on board ship.

At this point Sir John E. Thornycroft stated that there was a crushing plant with a heater available which made the use of separate driers quite unnecessary.

Cast-iron of good quality was, Mr. Muller thought, the material used for the fire-bars. The system was not an entirely automatic one for, as was pointed out in the paper, large clinkers must be removed through the furnace doors. Where Scotch boilers were installed two were to be preferred to one, but if water-tube boilers were to be used instead, one only might be quite sufficient. The author of the paper agreed with Professor Dalby's remarks about separating the efficiencies of the heat production and utilisation in boilers, and the reason why more stress was not laid on it was that for a proof of the value of the stoker a general working comparison of a boiler with the two type of stoking was what was needed. In a four-boiler ship the firemen on each watch could be cut down to two, and possibly, to one. He concluded by stating that the work of applying Underfeed stokers in the way suggested in the paper was an action in which the work of engineers of both Britain and Holland was combined.

Sir Archibald Denny commented on the service rendered to engineers by conducting research work such as that of Mr. Muller, who, he said, had the control of 400,000 tons of shipping in 100 steamers He then moved a vote of thanks to the author.

Compound Internal-Combustion Engines.

A paper on "The Method of Obtaining Increased Expansion for the Gases of an Internal-Combustion Engine by Passing them into a Low-Pressure Turbine" was then read by Professor Dalby, in the absence of the author, Lieutenant-Colonel Modugno. Of this paper we append a brief summary.

Many investigators had studied the possibilities of using compound working for gas and oil engines in order to obtain the limitation of the use of high pressures to a comparatively small cylinder and to carry out the final stages in one only subject to low pressures, and therefore of reduced thickness. Savings were anticipated also in the weights of pistons, connecting rods, crankshaft and the frame. Compound working had so far given results inferior to those from single expansion engines.

The substitution of a turbine for the low-pressure cylinder was thought to offer a solution of the difficulties and disadvantages. Turbines were better constituted to make use of small falls of pressure than reciprocating engines, and had been successfully employed in connection with aircraft motors to drive a compressor to supply air for the cylinders when in use at high altitudes. W. Schmidt proposed in 1916 to divide the work of an internal-combustion engine between a high-pressure cylinder and a low-pressure cylinder or turbine. In that scheme of working the second cylinder was introduced to perform the compression of the air to a value between two and four atmospheres before passing it into the high-pressure cylinder. Lieutenant-Colonel Modugno suggested an improvement on Schmidt's system by continuing the expansion action in the cylinder until a lower pressure was attained, but to use the same pressure for the exhaust. The resultant effect was a fall of pressure at the start of thesuction process at the beginning of the stroke, but the compression was performed in the cylinder rather than in a separate compressor. The only change in the indicator diagram as compared with that of the normal cycle was the removal of a small triangular area from the underside of the toe of the figure, which was rather more than compensated for by the work done in the turbine. The theoretical estimated gain was about 4 per cent. If the same size of high-pressure cylinder as that of the Schmidt engine were used it would be necessary to increase the exhaust pressure still further. The introduction of a compressor in that case would be a necessity. It would also be required in the case of a two-stroke cycle engine, as exhaust and admission took place simultaneously and a higher pressure was required for the scavenge blast than that of the exhaust. Some alterations would also be called for in the normal design of two-stroke Diesel engines.

Engineer-Commander C. J. Hawkes observed that no comment had been made by the author about the Junkers engines developed before the war. The system the author proposed appeared to him to be little more than a case of throttling the exhaust, in which case the temperatures throughout the cycle would be raised and the consumption would increase. Development towards simplicity was what should be aimed at and the suggestion of the author was not one of that nature. The heat contents of exhaust gases could be utilised to obtain increased power in other and rather better ways.

The chairman then moved a vote of thanks to the author.

The Theory of Bending.

The author, Professor Hovgaard, of the last paper of the session, which was on "The Theory of Bending," was also absent, and Mr. W. J. Luke briefly referred to the problem involved and the nature of the suggestion made by the contributor. Mr. G. S. Baker also spoke of the difficulties in the calculations of the strength of girders built up from materials with differing moduli of elasticity, and pointed out that work on the same problem had been done at the National Physical Laboratory.

After a vote of thanks had been accorded to the author and to Mr. Luke for his exposition the meeting was closed.

Later in the same day the show rooms of Mutters' Decorative Works at The Hague proved of great interest to the party. Many models of ship panelling and furnishings as well as actual examples of high-class Dutch design and workmanship were shown.

His Excellency the British Minister at The Hague, Sir Charles Marling, K.C.M.G., and Lady Marling, gave a reception at the British Legation to the members of the Institution on Wednesday night, September 5.

Visits to Works in Rotterdam.

Thursday was devoted to visiting four works in Rotterdam. The first was Werf Gusto, of which the chief products are large floating cranes, dredgers of all kinds, excavators, barges, cargo and passenger steamers. A floating crane of 200 tons capacity with a supply station on board for the provision of its electricity requirements proved of great interest. The crane is mounted on a high conical tower, which rises above the deck and is bolted securely to the ship. The crane can be slewed completely round the tower, and as the jib is connected on the one side by hinges and on the other by tie rods and screwed spindles, it can be moved up and down to any suitable angle.

The next works visited was that of the Rotterdam Drydock Company. There are six shipbuilding berths of lengths up to 600 ft. at this yard, and in one of them the construction of an oil tank motor ship of about 7,000 tons deadweight capacity has been commenced. This vessel is an example of the Millar system of construction. For repair work the harbour is provided with 10 quays giving easy access to the ships and providing facilities for obtaining electricity supply and compressed air. Portable electric welding plants and others erected on boats give every possibility of getting at the work to be done. The three floating docks of the concern have lifting capacities of 5,000, 8,000 and 15,000 tons respectively.

The garden village of Heyplatt has been built beside the works and planned with the aim of making it picturesque. Varieties of style are shown, but there is very effective harmony in the whole. The

public buildings and grounds are equally attractive and consist of a church, schools, baths, laundry, library and reading room, sports ground and swimming pond, and a hall for gymnastics and technical evening classes. In the planning of this community everything possible has been done by the Rotterdam Drydock Company to preserve the health, the comfort and the convenience of the workpeople, and the village would stand high in any estimate of the attractiveness of garden city schemes.

The New Waterway Shipbuilding Company is a concern only nine years old. It was started under difficulties, for material was not easily obtained, and a large floating dock which was purchased from a firm of North-East Coast shipbuilders was requisitioned by the British Government. The first keel was laid in 1916 and was that of a 7,200-ton steamer for British owners. While new work was then difficult, repairs were effected to many of the British steamers running between Rotterdam and Great Britain. There are now seven building berths, and vessels up to 950 ft. length can be constructed. Since 1918 this concern has built 14 vessels of between 7,200 and 12,500 tons. There is a large harbour beside the works where there are three floating docks.

The last visit of the day was to the works of Wilton's Engineering and Slipway Company. There the forge is of sufficient capacity to make the works quite independent for heavy forgings up to the largest sizes. The iron foundry can deal with castings up to 20 tons. An oxygen-producing plant of sufficient capacity to supply 1,800 cub. ft. of gas per hour is available. There are three floating docks in the harbour of 4,500, 8,000 and 14,000 tons lifting power. For ship repair work there is a slip for hauling up vessels sideways. It is of 330 ft. long. The slip consists of 20 carriages, each connected to a winch of 10 tons lifting capacity. These winches are electrically driven through a line of shafting with which it is possible to use the number of winches required for any size of vessel. Four floating cranes are installed, of which the largest has 100 tons lifting power at 40 ft. radius. Dredgers with buckets up to 45 cub. ft. capacity have been built at this works. A floating dock of 694 ft. length is an important item in the equipment.

On Friday a visit was made to the Nautical Institute and Museum at Rotterdam. This institution is maintained by the shipbuilders and contains a first-class library and an unique collection of models.

The party later proceeded by ferry to the works of Messrs. Burgerhouts' Engineering and Shipbuilding Company. The first demonstration was the hauling up of a vessel on a slipway, which is of the side type. It is equipped to haul up barges up to 400 ft. length and sea-going ships up to 4,000 tons deadweight. The building berths are three in number, of which two can be used for specially wide pontoons or dry docks. There were two steel barges approaching completion at the time of the visit.

THE DINNER.

The Institution held its dinner at the Hotel Kurhaus, Scheveningen, on Friday evening, September 7, when His Grace the Duke of Northumberland presided. Among the distinguished company present there were the British Minister at The Hague and Lady Marling, Sir Archibald and Lady Denny, Sir Thomas and Lady Bell, Sir Charles and Lady Ellis, Sir Westcott and Lady Abell, Sir Ernest and Lady Glover, Sir John E. and Lady Thornycroft, Baron and Baroness van Haersolte, Sir Alexander Gibb, Sir George and Lady Renwick, Count and Countess van Heert tot Eversverg, Professor Everts, Mr. and Mrs. Lambrechtsen, Dr. A. G. Kroller, Mr. and Mrs. Francis Henderson, Mr. D. Goedkoop, Mr. and Mrs. A. J. Campbell, Mr. L. Peskett, Mr. and Mrs. H. E. Yarrow, Mr. and Mrs. Luke, Mr. and Mrs. Dana, Professor and Mrs. Dalby, Professor Hillhouse, Mr. and Mrs. Ryus, Mr. Jan Smit, Mr. and Mrs. Burgerhout, Engineer-Commander Hawkes, Mr. A. C. F. Henderson, Mr. Van Hoogstraten, Mr. J. Foster King, and Mr. W. J. Muller.

Of the loyal toasts, the Duke of Northumberland proposed that of the "Queen of Holland," and Professor Everts that of "King George." Then His Excellency Sir Charles Marling, K.C.M.G., presented the toast of "Shipping and Shipbuilding in Holland," which was replied to by Mr. B. E. Ruys, president of the Nautical Institution and Museum, and by Mr. Lambrechtsen.

The Duke of Northumberland, in speaking to the toast of "Our Guests," said, no words could adequately express their feelings of gratitude to the Reception Committee, for no visit could have been more carefully arranged, and no proceedings could have worked more smoothly. Their visit to Holland would stand out as perhaps the most successful of all. That it was so was due to the untiring efforts of many working in co-operation with one another, and especially to Baron von Haersolte, Professor Everts, and Mr. Lambrechtsen.

The ship-builders of the two countries had the same problems, and common action in their solution brought them together in the best way possible. Such visits as theirs would do much to clear away misunderstandings and destroy distrust between nations.

In his reply Professor S. G. Everts spoke of the value of professional fraternity in the improvement of ship design and referred to the problems in the latest form of transport which must confront the engineer in the design of airships.

Dr. A. G. Kroller proposed the Institution of Naval Architects, to which Sir Archibald Denny suitably replied.

The party left Scheveningen on Saturday morning, September 8, and after lunch at the railway station at Flushing, when able speeches were made by Baron van Haersolte and Mr. van Hoogstraten in reply to the thanks of the members expressed by the Duke of Northumberland, proceeded by the ss. "Prinses Juliana" of the Zeeland Steamship Company to Folkestone.

SANITATION IN INDIA.

THE science and art of sanitation has been practised by all nations who desired to retain their individuality and preserve their race. That great sanitarian, Moses, made and rigidly enforced sanitary laws most perfect and difficult to improve upon even at the present day. These laws contained elaborate directions for the preservation of health by scrupulous attention to cleanliness; and it is a remarkable fact that the Jews throughout their existence have enjoyed a wonderful immunity from diseases of the epidemic type, the only exception being when they have relaxed their vigilance in preventing near their dwelling-places that continuous deposition of organic matter so productive of disease. The code of Manu, and the Indian Sastras are based on sanitary laws, and those Hindus more particularly of the Brahmin caste, who have followed the precepts laid down by their Sastras, have preserved their individuality for over a thousand years, notwithstanding the numerous foreign invaders India has been subject to. In Ancient Greece and Rome considerable attention was paid to matters sanitary, and every question relating to "Public Health." The Romans were skilled in the science and art of drainage, and the drainage of the Coliseum is an example of the standard of efficient sanitation they had arrived at. The elevation, power, and culture of Greece and Rome in their zeniths, with their admirable laws and regulations which fully provided for the safety of the public health are a contrast to the degeneracy of the Dark Ages, which followed. The nation which is the healthiest and most vigorous physically and mentally will naturally assume the ascendancy in the world.

Wherever people congregate sanitation becomes a necessity, and the principal causes of the ills we suffer from are due to its neglect. Pure air, pure water and nutritious food are the three great agents for promoting life and health; any one of these once used or combined with matters of a deleterious character loses its vital properties and becomes as it were a poison unfit to fulfil its mission until it has been exposed to those revivifying influences which will restore its vital energy. It is the oxygen alone of the air that is utilised by animal economy, and air once used becomes unfit to sustain human life; so that air used up by organic matter undergoing decomposition becomes unfit to sustain life and health. It is perhaps not generally known that the memorable illness of our late King Edward VII. when Prince of Wales, when his life was despaired of, was due to the defective condition of the drains of the Royal Residence. This had the beneficial effect of stirring up the energies of scientific and practical men, and causing them to give their attention to the subject of sanitation, so that the knowledge of the source of our late King's illness led to many valuable improvements being made in sanitary appliances and arrangements, and to their readier adoption by the now enlightened public. The diseases and epidemics that we formerly ascribed to the will of Providence or Fate, are now shown to be due to our own careless indifference and neglect of sanitary precautions. Nature is a stern mistress, and an infringement of her laws is inexorably punished. It is, therefore, obviously the duty of those authorities who are responsible for a nation's health and welfare to strictly administer all rules and laws affecting public health. Local authorities are not always actuated by motives of humanity, money often being with them a greater consideration than the health of the unfortunate ratepayer. Dr. Parkes states: "It has been proved over and over again that nothing is so costly as disease, and nothing so remunerative as the outlay which augments health, and in doing so augments the amount and value of work done."

In India sanitation, according to Western ideas, has been comparatively recent, the ancient laws and Sastras provided sanitary laws for a rural population, where space is unlimited and the people had time and leisure for the observance of the laws laid down for cleanliness. In the present day the spirit of the law is often lost in the observance of its ritual. Other causes which retard the progress of sanitation in India, are the want of co-operation among the people, their poverty, and the apathy of the local authorities. The popular error, time-worn dogmas, the relics of an ignorant and superstitious past handed down from generation to generation as undisputable doctrine, are the other enemies to progress, because they find a ready acceptance, and prevent the seeking after knowledge. Education has been proposed as the panacea for the backward sanitation of the East; but has education even in our own country advanced the cause of sanitation? The basis of all sanitary achievement in India must be a knowledge of the people, and the conditions under which they live, both as regards their habits and customs and their surroundings. The three essentials: pure air, pure water, and nutritious food, are necessary, but there are tropical diseases which are conveyed from one person to another by various biting insects; and the advancement of sanitary science in the tropics requires a study of the life history of these insects, and of devising means of protecting human beings from their attacks. It is possible that strict attention to cleanliness may prevent the diseases that are carried by these insects, or modify their severity. Enteric fever, cholera, and dysentery are spread by flies and, to a limited extent, by dust. They are diseases related to excremental matter, and the early removal and disposal of such matter by sanitary methods is essential. Rubbish and litter in houses attract rats and spread plague, pointing to the necessity of clean, well-swept houses and grounds. Stagnant water in drains, hollows and recepticals becomes the breeding places of the Anopholes mosquito, which spread malaria. "Kala Azar" is due to the bite of an insect that is nourished by dirt and want of cleanliness. The dust from cow dung cakes in congested areas may spread tuberculosis, and so also may the habit of expectorating, so common to the people of India.

A protected water supply is looked upon as a matter of course in this country, which is not the case in India, where the people are generally careless and indifferent in their choice of the water they drink. Too often they wash their clothes in, bathe in, and drink from, the same source of water supply; and this habit is observed even among the higher castes. The supply in some cases may be abundant, but questionable from a strict sanitary point of view. In other cases the people have to go long distances to obtain water, and often take it from the nearest available source. It is possible that long use of such water has rendered the community

immune to the diseases produced by the use of such water, and the bactericidal action of the powerful rays of a tropical sun has also to be taken into consideration; but occasionally an epidemic, such as cholera, takes a heavy toll from the community. Unclean birds, the feet and mouths of cows, dogs and other animals, are often causes of contamination of a source of water supply; and the same may be said of the hands and feet of men, dirty pots and ropes, rags, etc., in the act of drawing water.

In drawing up a scheme for the supply of water to an Indian community it is advisable to ascertain from the people their usual source of supply, and then endeavour, if possible, to protect and purify it. The people have certain peculiarities in the selection of the water which they consider good for the body, and generally prefer running water, or water collected in lakes and ponds to water obtained from wells; possibly because their "Sastras" have told them that running water is self-purifying, and also because the water in streams and ponds is softer than well water and more suited to a people who from reasons of caste or necessity are vegetarians. The first essential is that the scheme must be a cheap one, and the partial immunity of the people, and the effect of the sun's rays should receive consideration in the cost of protection. A typical safe water supply may be held to be an underground water supply derived by filtration through a clean soil, at such a distance from habitations as to be beyond risk of contamination through the soil or sub-soil. Where the supply is from tanks or ponds, the environs must be fenced and protected from pollution, and the water raised by mechanical means to a service reservoir, and distributed by means of pipes and public fountains. In the case of streams and rivers it is advisable to raise the water into settling basins, where it is purified by sedimentation and isolation, generally from seven to ten days, but at least for 48 hours, the distribution being effected by pipes and public fountains. Sand and mechanical filters are expensive to install, and unless worked by trained men are not desirable. For very small rural communities protection is obtained by selecting a source free from contamination, and protecting its environs by fencing or other means. A set of high-caste accredited water-drawers are appointed and provided with iron buckets and clean ropes. These men draw the water and store it in large new earthenware pots, and distribute it into the people's hands or pots through split bamboos, so that no water splashes back from the receiver's hands or pot, on to the water-drawer's hands or bucket. In the case of the larger Indian towns the usual methods of design and distribution are followed; but unless the town is provided with an efficient drainage system, the water supply should be limited to actual requirements, and no waste of water allowed. Too often the introduction of a water supply to an Indian town, although it has reduced the mortality from cholera, yet has lowered the general health of the town by raising the sub-soil water level.

In the sewerage of a town three distinct operations have to be performed, drainage of the surface, drainage of the sub-soil, removal of fæcal and liquid refuse. The original purpose for which sewers were used in this country and in Europe was to carry away surface water, but when towns began to expand in their proportions, it was found convenient by some to use the sewer for getting rid of excreta. In course of time it was found that this mode of dealing with the excreta of a town had its advantages, and it was finally adopted in large towns, as being not only the readiest but least expensive method of dealing with town sewage. The objection to sewers is that as underground channels they allow the transference of effluvia from place to place. The healthiness of our houses is considerably influenced by the conditions of the atmosphere of the ground on which they are built, and this atmosphere is materially affected by the degree of pollution of the soil and sub-soil. Germinal matter deposited in contact with soil receives that development necessary for it to run its destructive career, and the conditions and temperature of our houses render them favourable ducts for drawing up out of a polluted soil those germs which are destructive to the health and the life of human beings. It is imperatively necessary, therefore, that all sewers and drains should be perfectly impermeable, and their perfect construction is a matter of no small moment if the purity of the ground water and ground air is to be secured.

Excluding rainfall from sewers may be justified on the ground of increase in the manurial value of the sewage, to obviate the inconvenience of purifying large and uncertain volumes of sewage, and to give the streams of the country their natural flow. Although in some districts it may be important to exclude the rainfall from sewers, yet in urban districts the first washings of streets and roofs of houses may be as impure as sewage itself, or even worse, as rain acts as a scavenger in washing the air, the surface of streets, yards, and roofs, and conveys away an immense amount of impurity; so that to prevent pollution to our streams it may be necessary to admit a proportion of the rainfall into the sewers. A limit has to be laid on the amount of rain that is admitted, as when sewage has to be purified the amount that can be economically dealt with requires careful consideration; also the combined rainwater and sewage may be all out of proportion to the dry weather flow; and there may not be sufficient velocity in the sewers during the dry-weather flow to carry forward the solid matter, and the sewer may become one of deposit. If the sewage has to be chemically treated the rainwater must be excluded as far as possible.

The position of the outfall of the drainage of a district, and the disposal of sewage is one of the most difficult problems which confronts the civil engineer. In no case is it desirable to proceed with a drainage scheme until the position of the outfall is definitely settled and secured. The disposal of sewage must be effected without causing a nuisance by polluting the air, the water of a river, or stream, or the sea. The Rivers Pollution Prevention Act prevents the injury and pollution of rivers by the discharge into them of refuse putrid solid matter, or other waste, or noxious or polluting liquid or solid sewage matter; but more stringent legislation appears to be necessary. Where sewage matter is discharged into the sea, careful float observations are necessary to ascertain whether under every condition of the tide the sewage can be carried away without causing a nuisance by polluting the foreshore either near the outfall or elsewhere. In the chemical treatment of sewage the sludge has to be disposed of, and the same difficulty arises in the bacterial treatment of sewage. Recently filtration through straw has been tried with some success, the straw being broken up into valuable manure. The most natural and economic method of sewage disposal is to put it on the land, and the recent experiments in the manufacture of gas for power, lighting and heat, from sewage and decomposing refuse opens out a new field of enterprise, and may lead to the prevention of congestion in cities and towns. Instead of the "super-power stations," which will be at the mercy of every strike organiser, each hamlet, village and township will from its own sewage and refuse, obtain light, heat, and power; and the comparatively small amount of sewage and refuse to be disposed of will enable its full manurial value to be obtained, so that it can be placed back on the land—its legitimate destination. Industries, instead of being concentrated, will be scattered, and labour will be available for the factory and for the land.

The simplest form of drainage in Indian villages and townships is represented by open surface earth drains; the house washings are generally let into these drains, and are carried away or sunk into the soil. The fields are used by the inhabitants for their conveniences. An improvement on this system of drainage is a system of open masonry drains to carry away rainwater and house washings, discharging into intercepting sewers, which carry the sullage to a selected outfall.

A complete sewerage system with house connections in accordance with European practice is quite unsuited to Indian towns, as even in the larger towns the majority of houses are of the most inferior form of construction, and even the houses of Europeans are not suitable for a closed sewerage system. Moreover, in most Indian towns the supply of water is limited, and would be insufficient for flushing purposes. Dealing also with the heavy rainfall which is confined to certain months of the year presents another difficulty. In India all private house and small branch drains should be as far as possible open when excremental matter is not carried by them. It is possible that the problem of sanitary engineering suitable for India will, in time, be solved, and a system evolved in which the main principles of sanitation will be embodied, but modified to suit Indian conditions. Changing by the stroke of a pen long-standing habits of a people is likely to prove abnormally expensive, and all out of proportion to the results obtained.

The question of the disposal of sullage and excreta in India is a complicated one. In the case of towns possessing a sewerage system, the correct place for the disposal of sewage appears to be the land, and there appears to be no proof of injury to health from a well-managed sewage farm; the most barren land can in a few years, by sewage irrigation, become rich arable and pasture land. Owing to the climate the sewage undergoes septic action in the sewers, and as in the most parts of India land is easily obtained, the simplest method of disposal is to put the sewage straight on to the land.

In the case of towns with a deficient water-supply, the drains should be open masonry ones to carry away rainfall and house-washings. The night soil should be removed daily in air-tight bins. If the inhabitants, both European and Indian, could be persuaded to use earth closets, a good deal of the unpleasant smell from the carts carrying away the night soil would be eliminated. Its final disposal is on the land, but here a difficulty arises. Nitrification proceeds actively only within the first 18 in. of soil, and the most active changes occur within 6 in. from the surface; but unfortunately the disposal of night soil in large quantities in shallow trenches has been found to produce flies; and it has been proved that flies can come to the surface through 45 in. of sand. It is possible that if the use of earth closets were insisted on the fly nuisance may be abated; but in the case of fairs and festivals where the fluctuating population may reach many hundreds of thousands a day, the problem of the best and most sanitary disposal of human excreta becomes a difficult one. Although there may be loss in the manurial value, and the process may not be so satisfactory from an economic point of view the safest and most sanitary disposal of such matter appears to be to burn it along with the town refuse. The smell may be objectionable, but with care in scattering the incinerators, the evil smell may be mitigated.

In the case of the disposal of town refuse the filling in of pits and swamps with it as a cheap method of disposal is incorrect, as during the process of fermentation, the air and sub-soil water are poisoned, as was exemplified in filling up the low lying places of Bombay with town refuse. If, from sanitary reasons, low-lying places, swamps and pits require to be filled up, they should be reclaimed with fresh soil.

Town refuse consists of street sweepings and household refuse, the latter consisting of house sweepings, vegetable refuse, paper, rags, broken glass, cinders, ashes, &c., and the sanitary disposal of such refuse forms an important part in the cleanliness of a town. Its manuring properties are doubtful, owing to the mixture of material not suited for the land. A process has been patented whereby the objectionable parts are removed by centrifugal action, and the remainder converted into a fertilising agent. Its installation in India may be expensive, and for that country and also for the smaller European towns the most satisfactory method appears to be to burn such rubbish and then utilise it for filling up low-lying land, hollows and pits.

In laying out an Indian town or village which is not provided with a complete sewage system, the main roads should be as straight and wide as possible, running, if practicable, in the direction of the prevailing wind. These roads should be provided with earthen drains for carrying off storm water. The back streets or conservancy lanes, which will serve the back yards of houses should be not less than 8 ft. in width, and should be provided with masonry drains on either side for carrying off

PARAFFIN MARINE ENGINES AT THE OLYMPIA EXHIBITION.

CONSTRUCTED BY THE PARSONS' MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.

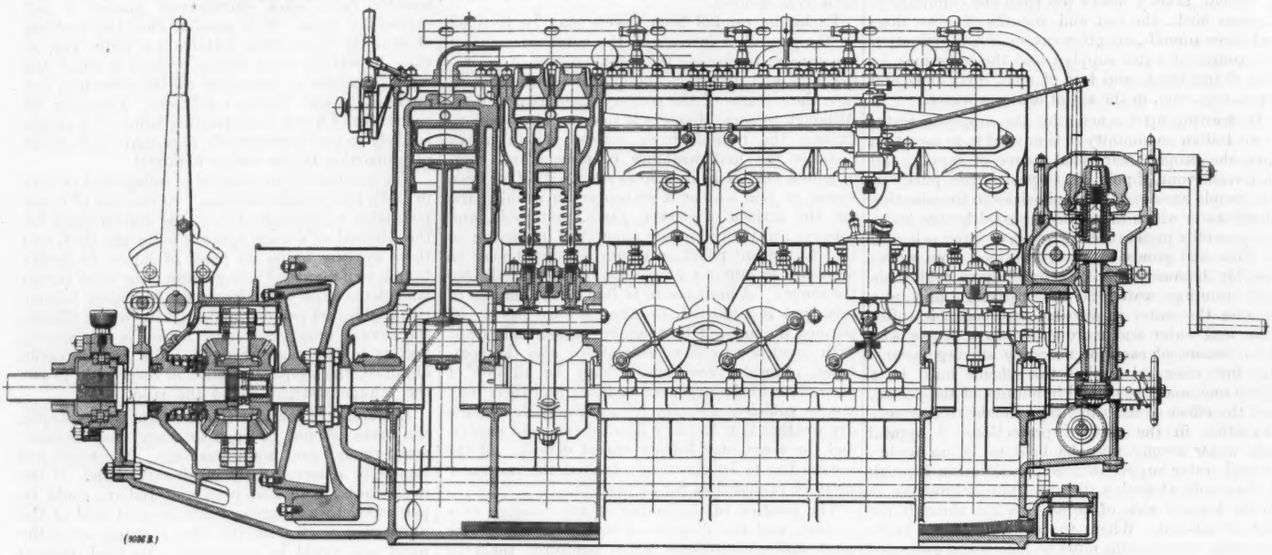


FIG. 64.

the house washings to intercepting sewers. These lanes will be used by the conservancy carts for carrying away the house refuse and the night soil which should be collected in pans and tins and cleared every day. The greatest congestion occurs among the working classes in factory towns, which are made up of different divisions of the backward classes, and each division is governed by its own customs, habits and prejudices. For this reason there is a necessity for housing each class according to a particular method, the main consideration being that the sites of their houses must be within walking distance of their markets and supplies, and of their work. The ordinary Indian factory-hand cannot even afford 2*d.* (two annas) a day for transport. When the process of obtaining power, light, and heat from sewage and refuse has been perfected, it is possible that industries may be scattered instead of being concentrated, and the work of the sanitarian will then be considerably lightened, and fresh air, light and space will be available to all communities. Such an ideal state of affairs would be easier to introduce into India at the present time, when the bulk of the people are agriculturalists, than at a later period, when the glamour of the industrial development of the country has drawn labour into the large towns.

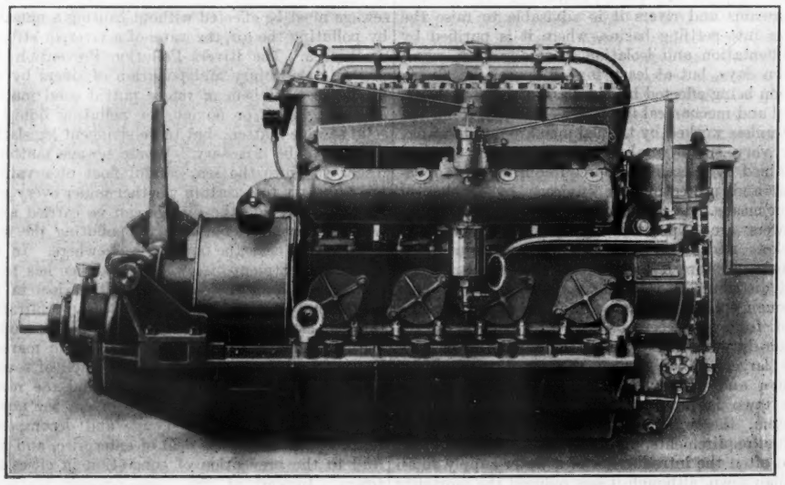


FIG. 65.

THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

(*Continued from page* 297.)

IN addition to the exhibits of The Parsons Motor Co., Ltd., of Town Quay, Southampton, which we illustrated in our issue of September 1, the firm are showing a six-cylinder 42 b.h.p. marine paraffin engine combined with clutch and reverse gear as a single unit. This arrangement has been standardised in connection with the 4·5-in. cylinder engines, which range in power from 14 to 42 b.h.p., depending upon the number of cylinders. We illustrate the 42 b.h.p. engine, partly in section, in Fig. 64, above, from which the construction of the gear and of the mechanical details of the engine will be seen, while the external appearance will be gathered from Fig. 65, which reproduces a photograph of a 28 b.h.p. four-cylinder engine of the same type. The control is effected by a single lever, which can be held by a detent in either of three positions in its quadrant, corresponding respectively to "ahead," "neutral" and "reverse." When the control lever is in the central position, both the cone clutch and the external brake band are disengaged and no power is transmitted to the propeller. When the control lever is moved ahead, the wedge forks which embrace the shaft just in front of the after bearing are released, and allow the cone-clutch and the whole gear-box to be moved aft by the action of the spring. The clutch cone, therefore, engages with the female part bolted to the rim of the flywheel, and the propeller shaft runs in the same direction as the engine. When the control lever is moved astern the clutch is not moved longitudinally into engagement, but a band-brake is tightened round the drum containing the gearing. The drum, and consequently the cross-shaft carrying the intermediate bevel gear, is thus prevented from rotating, with the result that the engine drives the propeller shaft by means of the bevel gear on the reverse direction, without alteration in speed. Under no conditions is any pressure from the clutch spring transmitted to the engine crankshaft, the abutment in all cases being a ball-thrust bearing.

The propeller thrust, both ahead and astern, is taken by a ball-thrust block at the after end of the engine. This bearing is bolted to the main casting of the engine and gear-box, and is machined accurately in line with the engine bearings. The propeller shaft does not move endwise under any conditions. The flywheel is covered by a light guard, and the only part of the external mechanism containing oil is the reverse gear-box, which is fitted with a screwed plug for filling. The crank chamber extension has holes in it so that it shall not retain oil or water. The reversing gear can be readily removed for inspection by removing the nuts from the cone-clutch studs and unbolting the thrust-block casting. The whole of the gear can then be removed without moving or interfering with the engine. The Parsons Motor Company also fit a reversing gear incorporating a reducing gear, so that a low propeller speed can be obtained with a high speed engine. The standard speed reduction is 2·5 to 1.

Referring to the engine generally, the cylinders are cast independently and fitted with side-by-side valves operated from a camshaft in the usual way. The cylinder-bore is 4·5 ins. and the stroke 6 ins. The engine will develop its rated power of 7 b.h.p. per cylinder, at a speed of 850 revs per minute, but the speed can be raised to 1,100 or 1,200 per minute if required, the power, of course, increasing proportionally. The fuel used may be petrol, paraffin or alcohol, and the makers guarantee the consumption both of fuel and of lubricating oil. The

ELECTRIC WELDING AND HEATING PLANT AT THE OLYMPIA EXHIBITION.

CONSTRUCTED BY MESSRS. BUCKLEY, SAUNDERS AND CO., LIMITED, ENGINEERS, LONDON.

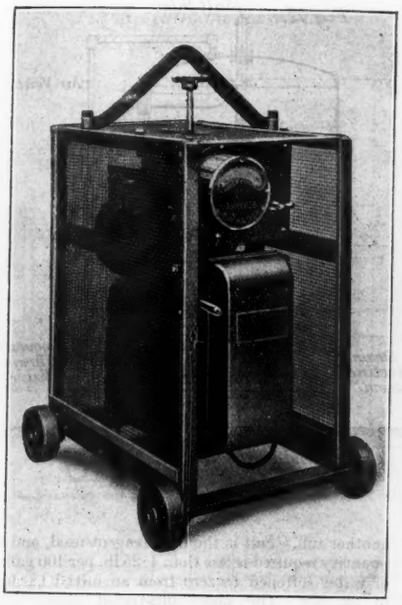


FIG. 66. ARC-WELDER USING ALTERNATING CURRENT.

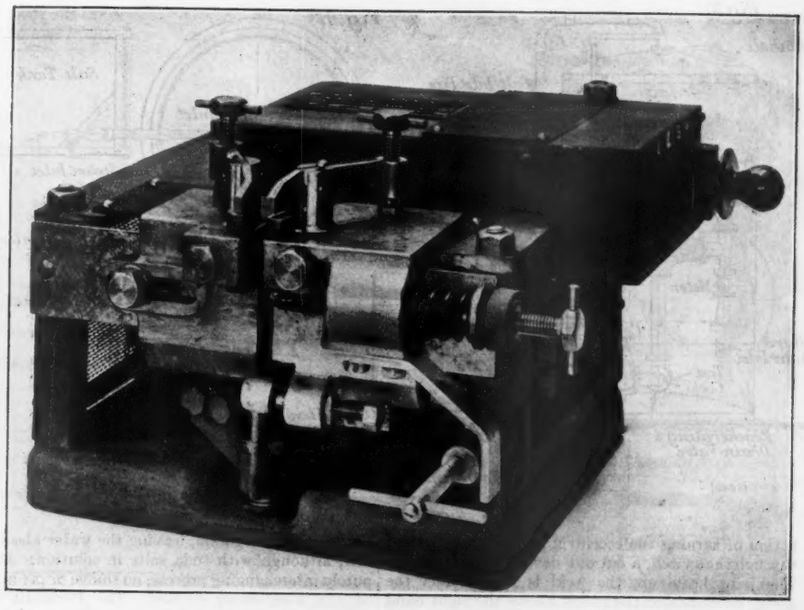


FIG. 67. STANDARD 3-KW. BUTT-WELDER.

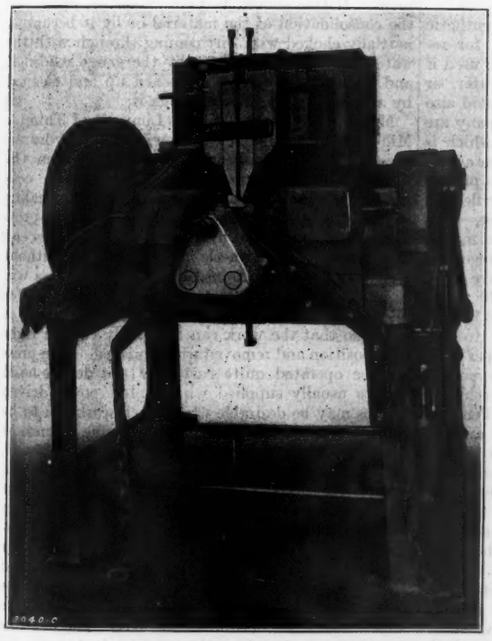


FIG. 68. CHAIN-WELDING MACHINE.

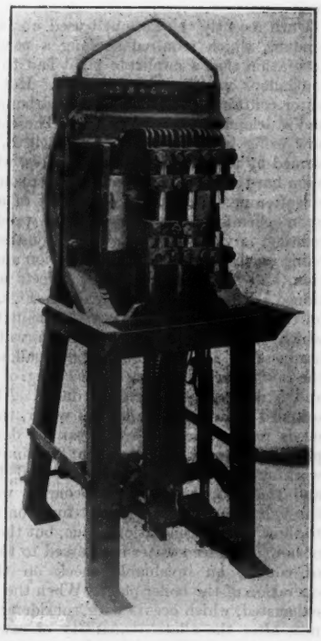


FIG. 69. ELECTRIC HEATER FOR RIVETS.

cylinders, crankshaft and connecting rods all conform to the requirements of the Board of Trade and of Lloyd's Register, and all engines of the type built by the Company will fulfil Admiralty, War Office, and other Government Departments' specification.

Messrs. Siemens Brothers and Co., Limited, of Caxton House, Westminster, make an imposing display, jointly with Messrs. Elliott Brothers (London), Limited, of Lewisham, of apparatus connected with the operation and control of ships. Engine-room telegraphs operated electrically and independently of the ships, mains, revolution indicators, directional and otherwise, helm indicators, look-out indicators and navigation lights indicators, all designed to keep the navigating officer on the bridge constantly informed of the state of affairs with which the instruments are concerned, are to be seen on the stand. Loud-speaking telephones to provide verbal communication between the bridge and the engine room and other parts of the vessel are also shown. All the current for the telephones is supplied from dry batteries, the current being so small that a battery will last for about twelve months. Wireless transmitting and receiving sets are included in the exhibit, as might be imagined, and there are also pyrometers for taking temperatures of exhaust gases of internal-combustion cylinders, funnel gases, fuel tanks, cold stores, and other duties on board. The old Siemens water pyrometer, used for obtaining furnace temperatures by noting the rise of temperature of the water when a piece of metal raised to the furnace temperature is dropped into it, still finds a useful place in metallurgical work and may be inspected on the stand.

Electric welding plant, suitable for use in the arc and butt processes, is shown on the stand of Messrs. Buckley, Saunders and Co., Limited, of 8, Princes Street, Westminster. Three representative machines and an electric rivet-heater, manufactured by the same firm, are shown in Figs. 66 to 69, on the present page.

Arc welding with alternating currents has found increasing use in this country because of the ease and simplicity of regulation to obtain the desired results. The machine shown on Fig. 66 was designed for use with alternating currents, and has a suitable transformer to reduce the pressure to the value required for striking the arc. The regulation of the current is afterwards effected by the use of a choking coil. Variable choking action is obtained by alterations in the length of the air gap in the iron core. A hand wheel is fitted above the plant, with its shaft passing through the steel plate cover, for use in changing the length of the air gap. The adjustments of current obtained range from 30 to 200 amperes. The whole outfit is mounted on a steel frame base and side structure carried upon wheels for convenience in moving about the shops. Mesh panels are fitted to give protection to the electrical equipment.

The machine shown in the next illustration (Fig. 67) is a 3 kw. standard butt welder. It is suitable for welding copper up to $\frac{1}{2}$-in. diameter continuously and for occasional service with thicker rods up to $\frac{5}{8}$ diameter; brass and mild steel wire may also be dealt with. The job is placed between the two jaws, the positions of which may be adjusted to suit the different sizes of material. The jaws are mounted on slides on the front of the machine. The right hand slide is movable but held in position by the handle-controlled eccentric, the turning of which leaves the slide free to be pressed forward by the spring. When the machine is in use the gap is set for the width of the work. The eccentric handle is then turned and the spring pressure allowed to act. The

WATER SOFTENING PLANT AT THE OLYMPIA EXHIBITION.

CONSTRUCTED BY THE UNITED WATER-SOFTENERS, LIMITED, LONDON.

Fig. 70.

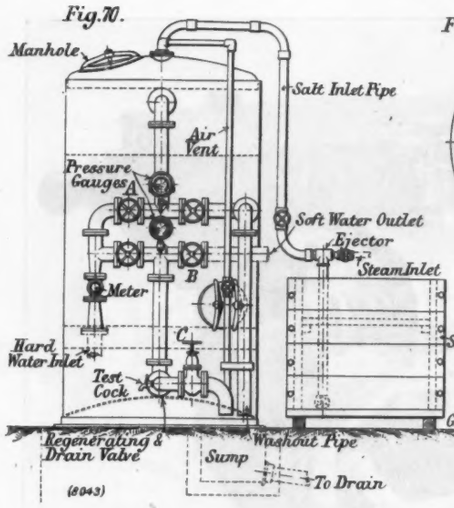


Fig. 71.

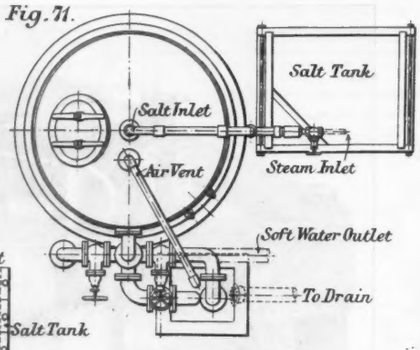
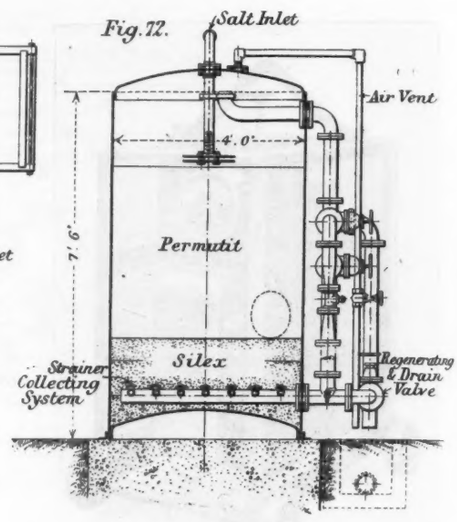


Fig. 72.



action of turning the eccentric puts on the current through the switch, a cut-out device being in series. The joint heats up, the weld is made under the spring pressure and the fusion allows the right hand slide to move forward. To prevent burning of the metal this action must be stopped when the current has passed a sufficient time for satisfactory fusion of the joint. This is ensured by having contact pieces which are separated when the work is cold, but come into action as the slide moves forward on the fusion taking place. They can be adjusted to suit any desired requirement. As the electrodes are copper bars they may be renewed at any time after loosening the screws. A chain-welding machine is illustrated by Fig. 68. The transformer is mounted on the back of the machine and the secondary transformer coils terminate in heavy electrodes, which are water-cooled and can be adjusted or removed for renewal. In this plant the transformer is so arranged that it can be moved forward to bring the electrodes on to the chain links without the use of any intermediate sliding electric contacts. The machine shown in the illustration will weld continuously either ordinary or block chain made from stock of $\frac{1}{16}$-in. to $\frac{7}{32}$-in. diameter at a speed of twenty links a minute.

Fig. 69 shows a 15 kw. rivet-heater with three heads. It has the usual equipment of transformer with a few heavy turns on the secondary to obtain a large heating current. The top heads are fixed to the frame of the machine, but the positions of the lower ones are controlled by the pedals in such a way as to give a parallel grip on the rivet no matter what may be its length. As the gap is under the control of the operators' foot no alteration other than what is effected in that way is necessary when working with rivets of different sizes. By the use of this machine ninety pounds of rivets can be heated in an hour with the expenditure of fifteen units of electricity.

Messrs. United Water Softeners, Limited, of Imperial House, Kingsway, London, are showing water-softening apparatus both of the lime-soda and the Permutit types. In the former the soluble calcium salts to which the hardness of water is due are converted into the insoluble calcium carbonate or chalk, which, after removal by settling and filtration, has to be removed periodically from the softener as sludge. After treatment, a few degrees of hardness generally remain in the water, which goes forward to the boilers carrying in solution a certain quantity of sulphate of soda which is comparatively harmless. The Permutit process consists in bringing the hard water into contact with a double silicate of alumina and soda, which is called Permutit. This substance gives up soda to the water and abstracts the lime and magnesia, leaving the water absolutely soft, although with soda salts in solution. It is a purely interchanging process, no sludge or precipitate of any kind being formed. The Permutit when exhausted is regenerated by contact with a solution of common salt, when a reverse action takes place, the Permutit being restored to its original composition.

Until recently the Permutit used was a synthetic product, which required so long a period for regeneration that a duplicate plant had to be used if continuous working was required. Hot water, or water containing much dissolved carbonic acid also had a deleterious effect upon it. The company are now using what is called "Permutit B," which is formed by refining the natural zeolites, whose action upon hard water first led to the interchange process of softening. It appears somewhat of a reflection upon chemists that the natural product, after refining, is vastly superior to the synthetic zeolite, being much more rapid both in action and regeneration, and free from the other defects above mentioned. The illustrations given in Figs. 70 to 72, on the present page, show a "Permutit B" plant which will reduce average London water to zero hardness at the rate of about 2,000 gallons per hour, the raw water containing about 17 deg. of temporary, and 5 deg. of permanent hardness. After having softened about 8,000 gallons of water, the Permutit needs regeneration, but this can be done and the plant got to work again in about 20 minutes. When working normally, the valves A and B are open and the rest closed. The incoming water passes through a meter, the primary function of which is to show when regeneration is due, but the knowledge of how much feed water has passed to the boilers is, of course, an invaluable check on the efficient operation of the boiler plant. When the Permutit is exhausted, which occurs with considerable definiteness after the allotted quantity of raw water has been softened, the inlet valve is closed and the valve C opened, the water being drained down to the level of the top of the Permutit. A 10 per cent. solution of common salt which has been previously prepared in the wooden vat alongside, is then passed into the softener by means of an ejector partially filling the space above the Permutit. Raw water is then let in at the top and the contents of the softener allowed to run away to waste. The passage of the salt through the Permutit restores the properties of the latter and the following water washes out any excess of salt. The effectiveness of the washing may be tested by shaking up a sample of the water with a few drops of soap solution, which will only lather if the salt has been properly removed. On completion of washing the plant is ready for another run. Salt is the only reagent used, and the quantity required is less than 1·25 lb. per 100 gallons of water softened to zero from an initial hardness of 22 deg. The plant illustrated works under pressure, but gravity plants are also made. The two pressure gauges shown, indicate by the difference in their readings the "loss of head" through the plant. If this should become excessive, either by the consolidation of the material or by it becoming partially choked with dirt coming through with the water, the fact is indicated by the gauge readings, and the material may be loosened up and cleaned by a reversal of the flow through it.

Messrs. Hollings and Guest, Limited, of Thimble Mill-lane, Birmingham, are showing three hydraulic presses, designed respectively for pressing on the solid tyres of commercial vehicles, for the cold bending of plates up to 6 ft. in width, and for baling old tin cans and other scrap metal. The tyre-press is provided with a slot in the head so that tyres can be pressed upon wheels when desired without removing the wheels from the axles. The press will exert a pressure of 200 tons, which is sufficient for the largest and heaviest tyres in use. A runway is fitted so that the work can be readily carried right into position and removed when finished. The press can be operated quite easily by the double-hand pumps usually supplied with it, but power-driven pumps may be desirable when much work has to be done. The bending press has a swinging column at one end, which can be detached from the head. This provision enables work to be pressed into a completely closed shape, and then slipped off the end of the press-head when the column has been swung out of the way. The bundling press comprises a rectangular cast-iron box, 27 in. by 15 in. by 30 in. deep, with a hinged cover, set in the ground so that the top of the box is at ground level. The hydraulic ram is beneath the box and raises a table which forms the bottom of the box. The old tins or other scrap metal are thrown into the box, the lid secured, and the hydraulic pressure turned on. As soon as the pressing is finished the cover is opened and the bale produced is ejected by the ram. The size of the bale is generally 27 in. by 15 in. by 6 in. thick, with a weight of 140 lb. Messrs. Hollings and Guest supply, for working the machines mentioned, a two-throw vertical hydraulic pump driven by chain and sprocket reduction gear from an electric motor.

Both the Yorkshire Copper Works, Limited, of Leeds, and Messrs. Allen Everitt and Sons, Limited, of Smethwick, Birmingham, show copper, brass, and alloy tubes and pipes in very great variety. The arrangements on the two stands are quite different, yet each contrives to make one of the most striking

OIL PUMP AT THE OLYMPIA EXHIBITION.

CONSTRUCTED BY MESSRS. WORTHINGTON-SIMPSON, LIMITED, ENGINEERS, LONDON.

Fig 73. SECTIONAL ELEVATION.

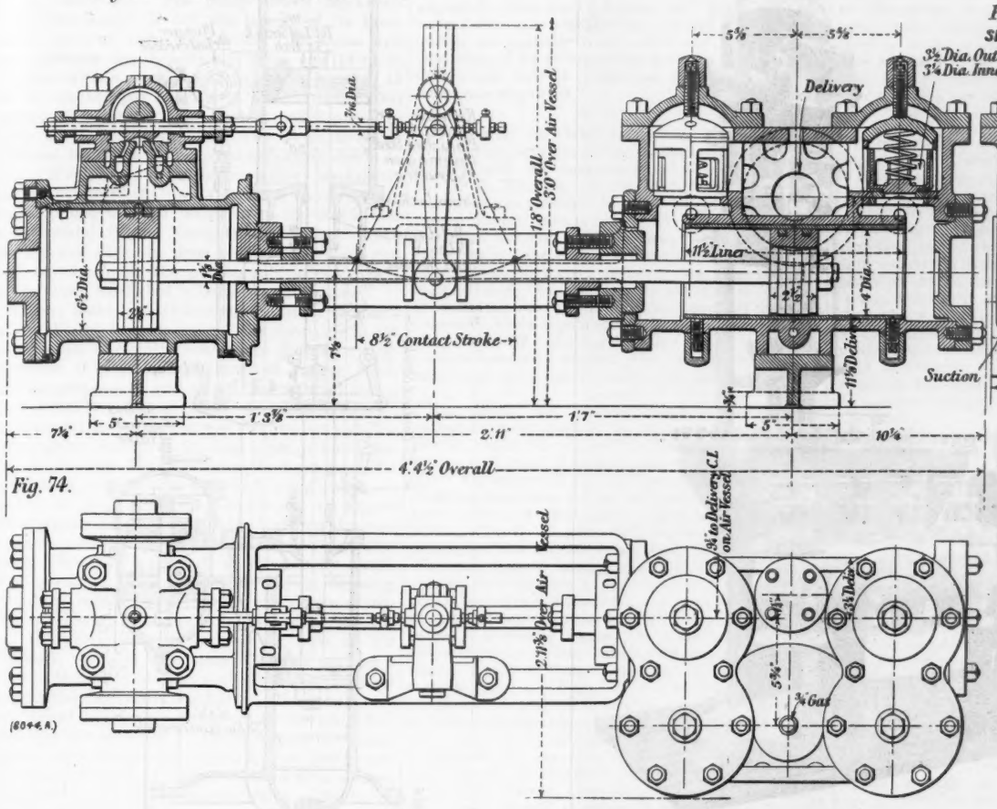


Fig. 74.

(6044.A.)

Fig. 75.
SECTION THROUGH OIL END

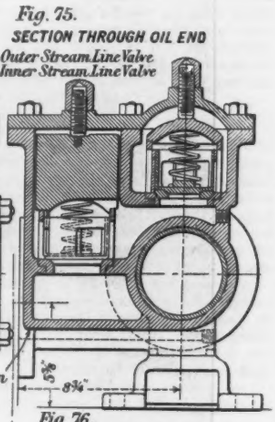
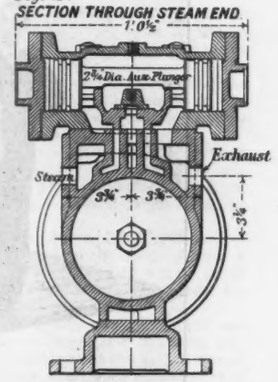


Fig. 76.
SECTION THROUGH STEAM END



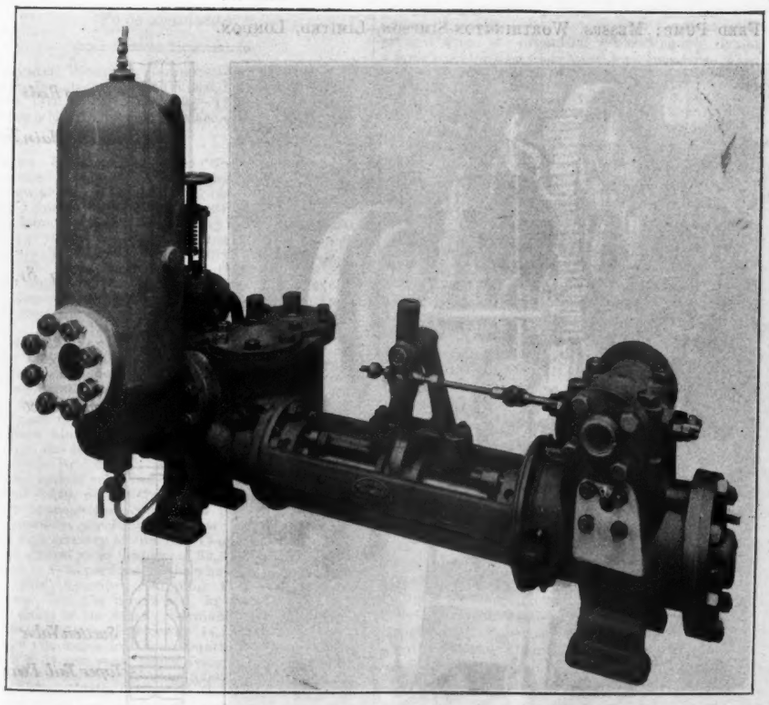


FIG. 77.

displays in the Exhibition. There is little that can be said in the way of a description of tubes, but both stands deserve inspection by those interested. Messrs. Allen Everitt and Sons, who specialise in condenser and locomotive tubes in cupro-nickel and brass, supplied the 70,000 tubes required for the condensers of H.M.S. Hood, the weight of the tubes exceeding 100 tons and the aggregate length 130 miles. The Yorkshire Copper Works, Limited, also exhibit numerous condenser tubes in brass, cupro-nickel and arsenical copper to British and other Admiralty specifications. Their stand contains a range of solid drawn copper tubes varying from 24 in. diameter down to 0·01 in. bore. A long length of the latter which is shown terminating in a glass of water through which air continuously bubbles after having traversed the whole of the tube.

Messrs. Worthington-Simpson, Limited, of Queens House, Kingsway, London, are showing pumps of various kinds for dealing with boiler feed-water, circulating water, fuel oil, &c. Figs. 73 to 77, annexed, illustrate a horizontal simplex oil fuel pump for delivering oil to the burners. The bores of the steam and oil cylinders are respectively 6½ in. and 4 in., the stroke of both being 8 in. The pump will deliver up to three tons of heavy Mexican fuel oil per hour. The valves are of the Worthington-Simpson stream-line design, each valve being composed of two parts, one having a seating within the other. The pump cylinder is fitted with a cast-iron liner a quarter of an inch thick, secured by set-screws and readily renewable. In the cross section of the pump it will be noted that the cage of the suction valve is held down by a solid block of metal kept in position by a set-screw projecting through the cover. The block has no other function than that of holding the cage, its form being dictated by the desire to reduce

PUMPING MACHINERY AT THE OLYMPIA EXHIBITION.

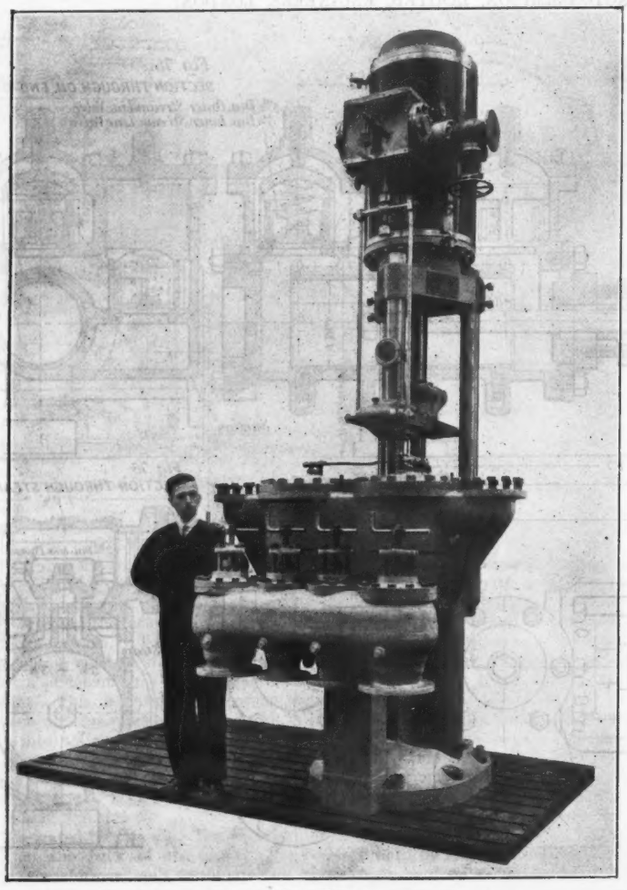


FIG. 78.

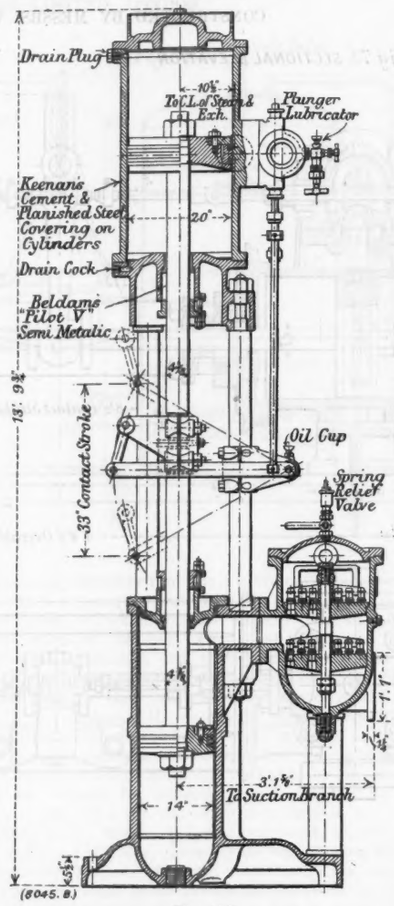


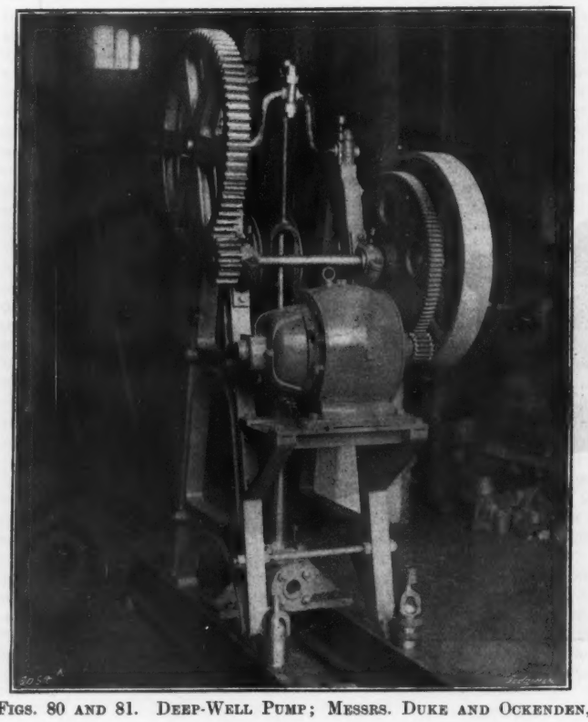
FIG. 79.

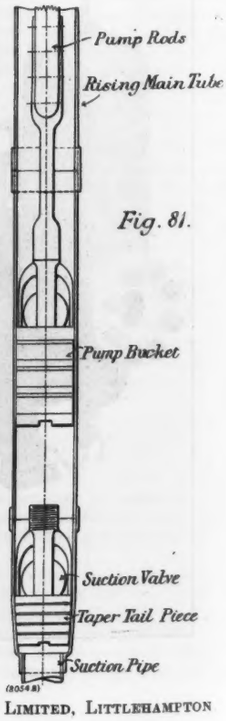
FIGS. 78 AND 79. BOILER FEED PUMP; MESSRS. WORTHINGTON-SIMPSON, LIMITED, LONDON.

the clearance space and render the valves and their seatings easily accessible.

The valve-gear, by which the distribution of steam to the cylinder is controlled is not very easy to follow from the drawings, but its general characteristics will be evident. The reciprocation of the piston rod gives a corresponding motion to a small slide valve, which is shown in Figs. 73 and 76. This positively moved valve works on the top face of a main slide valve, which has a transverse motion only, this motion being given to it at appropriate times by the double shuttle piston seen in Fig. 76. Live steam admitted at the pipe connection facing shown on the left of Fig. 76, can pass freely into the valve chest between the shuttle pistons, and its pressure holds both the positive slide valve and the main slide valve to their seats. The motion of the small valve admits steam to one of the ports passing right through the main valve, as shown in Fig. 73, and opens the other to the central exhaust port. The ports communicate each with one end of the shuttle piston, so that this is moved axially by the steam. In moving, it carries with it the main valve, which, travelling transversely under the small valve, admits steam from the valve chest to one of the ends of the steam cylinder, and connects the other end to exhaust. The consequent motion of the piston moves the small valve and a similar series of operations is again gone through. The steam-thrown shuttle uncovers its own exhaust ports at the end of each stroke, these ports not being visible in the drawing. When the shuttle is thrown it is cushioned by steam trapped in the cylinder ends, and thus works quietly and without shock.

The large boiler feed pump, illustrated in Figs.





FIGS. 80 AND 81. DEEP-WELL PUMP; MESSRS. DUKE AND OCKENDEN, LIMITED, LITTLEHAMPTON

78 and 79 on page 330, is also to be seen on the stand of Messrs. Worthington-Simpson, Limited, along with two others of smaller size, but of similar type. The pumps are of the double acting simplex design with valve gear similar to that illustrated in connection with the horizontal oil pump previously described. The pump shown represents one of the largest, if not the largest of its kind, which has ever been constructed. Its steam and water pistons are respectively 20 in. and 14 in. in diameter with a stroke of 32 in. At a speed of 12 double strokes per minute, it will deliver 23,000 gallons of water per hour against boiler pressures up to 300 lb. per square inch. This would be easily sufficient to feed a boiler plant supplying steam to about 20,000 kw. of turbogenerating machinery. Several pumps of the size in question have recently been supplied to ships belonging to the Peninsular and Oriental Steam Navigation Company. The suction box with the four screwdown valves and branches shown in the photograph, is not a part of the pump itself, but is bolted to the latter.

Messrs. Duke and Ockenden, Limited, of Ferry Wharf Works, Littlehampton, who specialise in the water supply of country houses, are showing a large collection of pumping apparatus of various kinds for that purpose, as well as a complete wind engine erected with tower on the stand. In addition to hand or power-driven surface pumps the firm are exhibiting pumping apparatus for deep wells or boreholes. Fig. 80, on page 330, illustrates the head gear of a bore-hole pump, the pump itself being shown in section in Fig. 81. The illustration is almost self-explanatory. A substantial cast-iron framing mounted on steel joists carries an electric motor which drives the crankshaft at the top by means of cut gearing. The connecting rod drives the pump rod which passes down through the centre of the bore-hole lining. The latter is screwed at the top into the suspension casting at the base of the standards, and acts as a rising main. A plunger is fitted to the pump-head to cushion the down-stroke and equalise the water discharge. The pump rods and bucket are counterbalanced by a rising and falling weight attached to the crosshead by chains passing over pulleys and guided by two steel rods. The pump barrel is of gunmetal fitted with a taper tail-piece to receive the suction valve. The latter can be withdrawn for examination when required, so that all parts of the pump are accessible at the ground level.

(To be continued.)

INDUSTRIAL WELFARE SOCIETY.—The fourth annual lecture conference at Balliol College, Oxford, will be held from the 14th to the 19th inst. The secretary of the conference is Mr. C. Cullen, 51, Palace-street, Westminster, S.W. 1.

CHELSEA POLYTECHNIC.—The Chelsea Polytechnic, Manresa-road, Chelsea, S.W. 3, has issued a leaflet giving particulars of the day and evening classes in metallurgy, to be held during the session 1923–24. The department contains laboratories for wet and dry assaying, metallography, pyrometry and heat treatment; it is proposed to give special facilities for foundry work during the session. The term commences on the 24th inst. The enrolling nights for evening courses are Thursday and Friday, September 20 and 21. Further data can be obtained from the Polytechnic.

LOSSES OF MERCHANT SHIPPING.—From returns just issued by Lloyd's Register of Shipping we learn that the total number of steamers, motor ships and sailing vessels totally lost, condemned, &c., during the first quarter of this year was 130, these vessels representing an aggregate gross tonnage of 161,019. In the case of Great Britain and Ireland alone, the losses were 26 ships, making 21,954 tons, the latter figure representing 0·11 per cent. of the whole British and Irish tonnage. The British Dominions, collectively, lost 14 ships with an aggregate tonnage of 6,640, during the quarter, the proportion of Dominion tonnage lost being 0·24 per cent. Of the foreign countries, the heaviest losses have been suffered by Italy, that country having lost 13 comparatively large ships with a total gross tonnage of 39,514, which amounts to as much as 1·38 per cent. of the whole Italian merchant marine. The American shipping losses amount to 25,848 tons, but the proportion, in this case, is only 0·18 per cent. of the total. Germany lost 17,636 tons during the quarter and Norway 14,256 tons, the proportions of the totals for these countries being 0·93 per cent. and 0·55 per cent. respectively. The only other countries with losses exceeding 5,000 tons are Japan, Spain and France, the figures for these countries being 10,983 tons (0·31 per cent.), 5,827 tons (0·45 per cent.), and 5,298 tons (0·14 per cent.), respectively. It is interesting to note that no Dutch vessel of any kind was lost during the quarter under review.

INDUSTRIAL NOTES.

THE Trade Union Congress concluded its sittings at Plymouth last Saturday, and the proceedings, taken as a whole, cannot be said to have produced any measure likely to benefit British labour directly or indirectly, either now or in the near future. In fact, the Congress appears to have been a barren one. There were also several altercations in the later sittings. The labour leaders are probably overworked, and it might be a good thing if for several weeks previous to a congress they could take a somewhat lengthy holiday to recuperate somewhat.

Continuing our brief review of the proceedings from our last issue, the session on Thursday, the 6th inst. opened with an emergency resolution moved by Mr. J. H. Thomas, on the Italo-Greek crisis; the resolution was seconded by Mr. J. R. Clynes, and was carried almost unanimously. We leave it there. A resolution was also carried "calling upon the general council to circularise all the trade unions, asking them to appeal to all their branches to use their influence amongst their own members to see that the women of their families at once become enrolled in their respective trade organisations." Unemployment was also dealt with, and one member stated that there were thousands of workers who were earning less in wages than the demands made by the unemployed.

Last Friday the Congress undertook the financial responsibility involved in the publication of the *Daily Herald*, and if the sum of 12,500*l.* required to finance it for a test period of three months be raised before the end of September the General Council was instructed to continue publication at least until the end of the present year. The co-operative dispute came up for review on Friday, when the clause in the General Council's report relating to this dispute was passed, the Co-operative Wholesale Society having agreed to refer all labour disputes to arbitration, in accordance with the report on the Co-operative Wholesale Society's proviso adopted by the Joint Committee on July 31. A resolution was passed "protesting against the total failure of the Government to produce housing schemes equal to the urgent needs of large numbers of working-class families . . ." Following this, the General Council put forward a proposal to give them power to intervene in industrial disputes and, if necessary, to raise funds by a call on the affiliated unions proportionate to membership to meet the expenditure of the council in relation to the disputes. This proposal was rejected almost unanimously. At this juncture Mr. Bowerman, the retiring general secretary of the Congress for the last thirteen years, was presented with an illuminated address and was voted a retiring allowance of 300*l.* per year. A motion by Mr. C. T. Cramp, of the National Union of Railwaymen, stating that the time had now arrived when the organised workers should demand a 6-hour working day was passed by a very large majority. The last resolution protested against "the proposals of the railway companies to further increase the workmen's fares and the cost of season tickets."

At the last sitting, on Saturday the 8th inst., the announcement was made that Mr. Fred. Bramley had been elected general secretary, in succession to Mr. C. W. Bowerman. A resolution condemning the continued occupation of the Ruhr by armed forces was passed unanimously. Seeing that the resolution referred to the "continued occupation of the Ruhr," we presume the Congress agreed to the occupation in the first place, but simply desired its discontinuance.

According to our information, the vexed question of the boilermakers' dispute was not dealt with, officially at all events, and this question, amongst others, is of far greater importance for British Labour as a whole than the Italo-Greek or the Ruhr matters, with which a British Labour Congress has no concern. We wonder what the General Council would say were a foreign Parliament, a Rigsdag, or a Folkething, to pass a vote of censure upon any decision it had taken. We believe it would ignore the vote and pass to the next question.

An article in *The Yorkshire Post* gives the views expressed by a member of the Federation of British Industries with regard to the Labour Congress here dealt with. It is an entirely false assumption, he says, that employers seek to break trade unionism. The loss of membership of the trade unions is due to nothing whatever beyond the fact that the members are fed up with the management and the perpetual subsidising of socialism. They are called upon to pay big levies out of small wages, and when they see that the *Daily Herald* has consumed 300,000*l.* and wants another 12,000*l.* to exist until Christmas, they begin to think for themselves. The Engineering Employers' Federation includes practically all the firms that matter in the engineering trade, and their policy is based upon agreements with the trade unions. No distinction is made between members and non-members as to hours, conditions and wages. Employers have certainly been driven to insist upon reduction of wages, because without those reductions men could not be employed at all. In the old days membership of a trade union gave some reasonable ground for assuming that the man was skilled in his particular trade and had served his time in the shop. To-day's trade unionism seems to mean that everybody who ever worked at the trade must be in the union and that he is very satisfactory if he has paid all his levies. As a result, an employer could have the shop filled with trade unionists and still have to search out the really skilled men.

In pursuance of section 59 of the Factory and Workshop Act, 1901, the Order of May 21, 1913, relating to the night employment of male young persons in those parts of factories in which reverberatory or regenerative furnaces are used, is rescinded by the Home Office, and in pursuance of Section 54 of that Act the special exception by which a male young person may be employed during the night shall extend, so far as regards young persons of the age of 16 years and upwards, to parts of factories in which reverberatory or regenerative furnaces are used in connection with (i) smelting of ores, (ii) metal rolling, (iii) forges, or (iv) manufacture of tubes, and are necessarily kept in operation day and night in order to avoid waste of material and fuel, subject to the conditions prescribed in sub-section (1) of the said section, and to the following further conditions:—

(1) The exception shall apply only to young persons employed in such processes requiring to be carried on continuously throughout the night as are defined in the certificate of the inspector hereinafter mentioned.

(2) Every young person employed in pursuance of the exception shall be submitted by the occupier to the certifying surgeon for the district once at least in every six months for examination at the factory.

(3) No young person who on examination is certified by the certifying surgeon, by signed entry in the register, to be unfit for such employment shall be employed again without the written sanction of the certifying surgeon.

(4) No young person shall be employed in pursuance of the exception unless and until the occupier holds a certificate from the inspector of the district to the effect that provision has been made to his satisfaction for compliance with the conditions specified.

Provided that any young person of 16 years of age or upwards who, prior to September 1, 1923, was employed at night, in pursuance of the said Order of May, 21, 1913, on premises where such employment is not authorised by this Order, may continue to be so employed as if this Order had not been made.

This Order may be cited as the Night Employment of Young Persons (Reverberatory or Regenerative Furnaces) Order, 1923.

THE BRITISH ALUMINIUM COMPANY, LIMITED.—This company has issued a calendar for the year from the current month to August of next year, the calendar showing the numerous sections of bars manufactured.

LOUGHBOROUGH COLLEGE.—The calendar for 1923–1924 of Loughborough College is a volume measuring 8½ in. by 5½ in., containing over 200 pages of illustrated information on the college and its activities. The college has two principal faculties—that of engineering, covering mechanical, civil, electrical, automobile and commercial engineering, and the faculty of pure and applied science. There are besides a junior college for boys, a school of industrial and fine art, and other very complete, well-directed and equipped departments for debates, sport and other entertainments, all of which form most useful adjuncts for the thorough education of young men. The next session commences on Friday, September 28, and ends on July 16, 1924. The book can be obtained from the college, at the price of 2*s.* 6*d.* net; it would prove of interest to all parents who at the present period of the year are considering "what to do with their boys."

EMPIRE MINING AND METALLURGICAL CONGRESS.—H.R.H. the Prince of Wales has consented to become Honorary President of the forthcoming Empire Mining and Metallurgical Congress, to be held at the British Empire Exhibition during the first week in June, 1924. The co-operating institutions are the Institution of Mining and Metallurgy, the Institution of Mining Engineers, the Institution of Petroleum Technologists, the Iron and Steel Institute, and the Institute of Metals, representing the scientific and technical interests of the mineral and metal industries, with the Mining Association of Great Britain and the National Federation of Iron and Steel Manufacturers, representing the colliery proprietors and iron and steel manufacturers respectively, of the British Isles. This is the first Empire Mining and Metallurgical Congress to be held, and it is anticipated that succeeding sessions will be held in the Dominions under the auspices of an Empire Council of Mining and Metallurgical Engineering Institutions, which it is hoped will be constituted as a result of the inaugural congress to be held in London next June.

DIESEL CENTRIFUGAL PUMPING PLANT FOR THE METROPOLITAN WATER BOARD.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER.

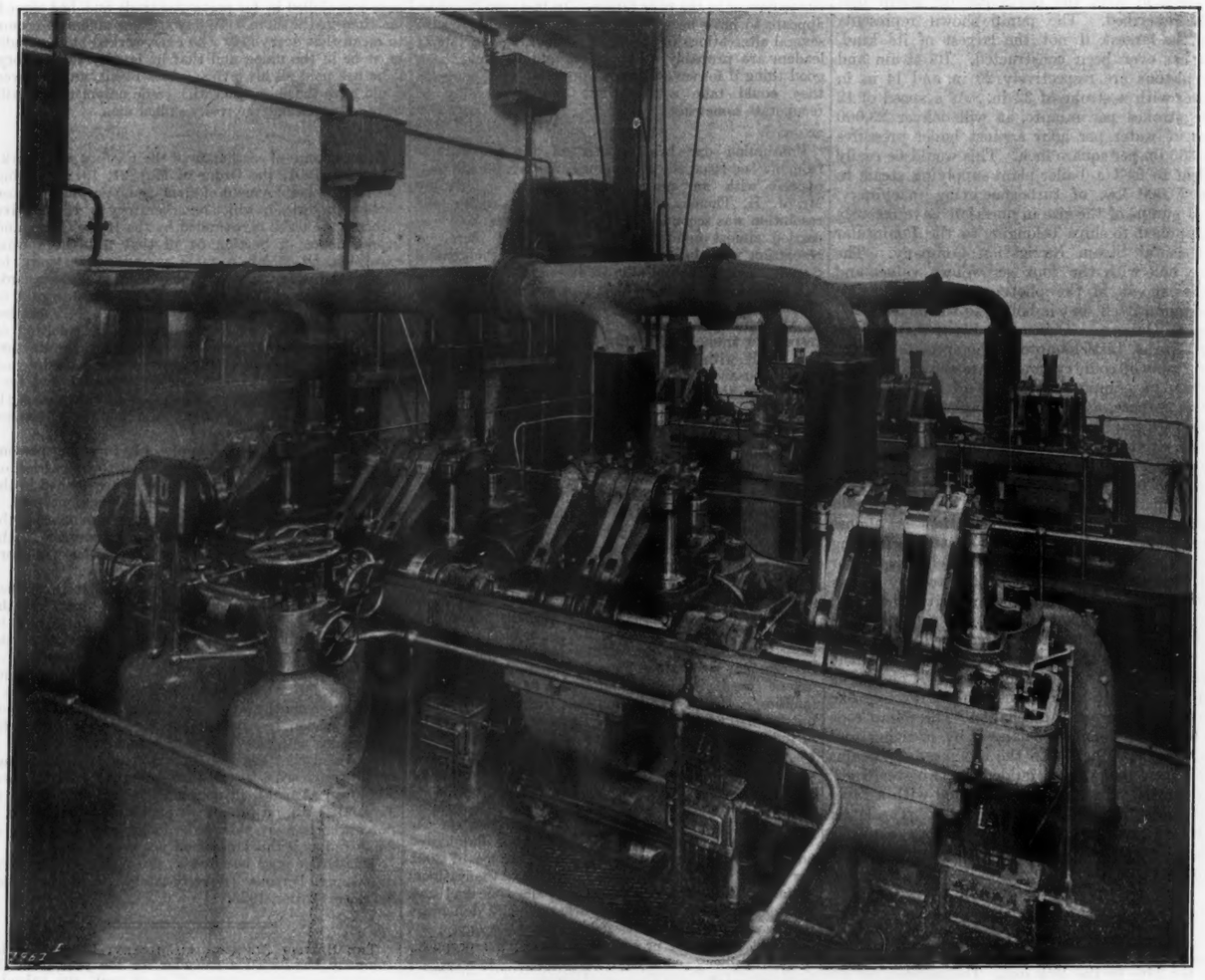


FIG. 8. STARTING PLATFORMS OF THE DIESEL ENGINES.

THE waterworks engineer of the present day has a considerable choice of systems when installing pumping plant. In the matter of the pumps themselves the choice may be between reciprocating or centrifugal pumps, or the displacement methods involving compressed air or internal combustion. The means adopted for driving may range between the reciprocating steam engine, the steam turbine, the internal combustion engine or the electric motor. Each of these combinations will be subject to modification according to local conditions.

Reliability is, of course, an essential, and this has for long been obtainable with the old-fashioned steam-driven plunger pumps running at 18 r.p.m. to 30 r.p.m. The plunger pump, however, is in many instances giving way to the centrifugal, which is a high-speed machine, but is very reliable owing to its simplicity and the small number of its parts. The centrifugal pump works best, however, at a speed at which direct driving is not as a rule suitable either by a steam turbine or an internal combustion engine without the use of gearing. On the other hand capital cost considerations would still favour the centrifugal, especially if combined with an internal-combustion engine. The latter, although rather more expensive as a driving unit has the advantage over steam prime movers by reason of the boiler, coal and ash-handling plant, &c., being cut out, to say nothing of the saving in space and buildings. The internal combustion engine further has the advantage of consuming no fuel when not actually working—no fires have to be kept banked, and standby losses are practically nil, while the engine can be started up at a few moments' notice and put quickly on full load.

Consideration for these facts resulted some time ago in the decision, when additional plant was required at the Hampton Pumping Station of the Metropolitan Water Board, to put in a Diesel-centrifugal installation, the first of its kind in any of the Board's pumping stations, and the work, which was executed under the direction of the chief engineer to the Board, Mr. H. E. Stilgoe, M.Inst.C.E., seems to have been attended by a marked degree of success. The room available for the plant was distinctly cramped, the space being that vacated by an old Bull engine. The new plant which we illustrate in Figs. 1 to 7, on Plate XIX, and Figs. 8 to 12 on the present page and pages 333 and 336, consists of two pumping sets, together capable of delivering in 24 hours 9,000,000 gallons against a head of 300 ft.

The main contractors for the plant were Messrs. Hick, Hargreaves and Co., Limited, Bolton and the Diesel engines were of this firm's standard design and manufacture. The pumps were made by and to the designs of Messrs. Mather and Platt, Limited, Manchester, while the gearing was supplied by the Citroen Gear Company, Limited, London. Figs. 1 to 4, Plate XIX, shows the lay-out of the complete installation, and will give an idea of the restricted spaces into which the plant had to be worked. The photograph reproduced in Fig. 11, page 336, shows how close were the limits which had to be worked to in the engine room, while the pumps were installed in an adjoining room as shown in Fig. 12, connection being made through the wall. The view reproduced in Fig. 8, above, shows the engine-starting platforms.

As already stated the Diesel engines are of Messrs. Hick, Hargreaves and Co.'s standard design, working on the four-cycle principle with air injection. They have open A frames and trunk pistons, and each develops a power of 400 b.h.p. at the moderate speed of 175 r.p.m. The cylinders have a bore of 18 in., and the stroke is 26 in., the rated power being developed with a cylinder mean pressure of about 91 lb. per square inch. This moderate pressure is conducive to a long service life of pistons, liners, &c.

One of the engines is illustrated in Figs. 5 and 6, Plate XIX. It is built throughout with heavy scantlings, and has exceptionally large bearing surfaces, the crank-shaft being 10·625 in. in diameter and the main bearings about 20 in. long. The crank-pins are 11 in. in diameter and 11 in. long. Lubrication has had particular attention and whilst the main bearings are of the usual ring-oiled type, and the crank-pin is oiled by a banjo ring, the supply to these oil boxes is continuous, through adjustable sight feeds from an overhead tank. All the oil drains from the bedplate into a small tank fitted with a filter. From this tank the oil is pumped up to an overhead tank to be used again. The system is thus automatic. All camshaft bearings are ring oiled, and all cylinders and gudgeon pins are positively lubricated from special plunger pumps.

The induction and exhaust valves are interchangeable, and are both made of a quality of steel suitable for the exhaust valve; the exhaust valve cage is water cooled. The valve levers are split in the usual way to facilitate dismantling. The cams are of cast-iron, chilled and ground. The fuel injection valves are of the sleeve pulveriser type, which the makers consider to be the best for dealing with a wide range of fuel. In this case the fuel valves are specially adapted to burn tar oil if required.

The fuel pumps and governor are driven from the vertical shaft, the quantity of fuel delivered being

regulated in the usual way by means of a sleeve operated by the governor, determining the lift of the suction valves, whilst the stroke of the pumps remains constant. Two fuel pumps are fitted, the delivery from each leading to two cylinders through a distributor. The air compressor for the blast air is a Reavell standard machine driven from an extension of the crankshaft.

From the above brief description it will be seen that every care has been taken to ensure the engines being able to maintain the rated load continuously, and the running records given below bear this out. The average value of the mechanical efficiency of this type and size of engine, as measured on the Froude water brake on the makers' test bed, is 75·4 per cent., which, of course, includes for the power used in driving the air compressor.

Table Showing Hours Running.

—	No. 1 Engine.	No. 2 Engine.	Percentage of Total Engine Hours in Month.
1922—			per cent.
December ..	688	351	69·8
1923—			
January ..	696	543	83·2
February ..	631	589	90·7
March	694	682	92·6
April	621	429	72·9
May	620	692	88·1

The main pumps are of Messrs. Mather and Platt's "Medivane" type, each set consisting of two 12-in. medium lift pumps in tandem running at 1,100 r.p.m., with the deliveries arranged in series. Fig. 7, Plate XIX gives a section of one of the tandem sets, with an elevation of the transmission gearing by which it is driven from the engine. The casing is of cast-iron of volute form. It is fitted with renewable zincless phosphor bronze neck rings, and carries a phosphor bronze impeller of the double suction enclosed type. With this type of pump perfect hydraulic balance is, of course, secured, rendering a thrust block unnecessary. The impeller is mounted on a steel shaft fitted with renewable phosphor bronze sleeves in way of the stuffing boxes. The bearings are of the ordinary split-ring oiled type.

The two pumps have one common shaft which is coupled up to the gearing by a pin and bush type flexible coupling, and the whole is mounted on one common base-plate. Fig. 9, above, shows the characteristic curve for the pumps as obtained from tests at the makers' works.

Both the Diesel engines were given a full load consumption trial at the works, when the figures obtained were 0·403 lb. per brake horse-power for No. 1 engine, and 0·39 lb. per brake horse-power hour for No. 2 engine. After erection on site the combined plant was subjected to a 5-hours' full load test under the supervision of the engineering staff of the Metropolitan Water Board, and the results of this test are shown on the diagram, Fig. 10. It will be noted that the consumption per brake horse-power was within the guaranteed figure during the whole trial. This test was carried out at the end of the maintenance period which demanded three months' continuous running with allowance of only 5 per cent. for adjustments, cleaning valves, &c. At the close of the official trial the Diesel plant, although originally introduced as a standby, took up regular full-load duty, which it did most successfully. The log shows that both engines ran on full-load night and day continuously for periods of 20 days to 30 days at a time. This is, of course, as rigorous a duty as even the engines of an ocean-going motor ship are called on to maintain. In fact, probably few motor ships afloat could improve on the record given in the annexed table of the total running hours of this plant, dating from the time the engines were taken over at the end of the maintenance period.

Fig. 9.

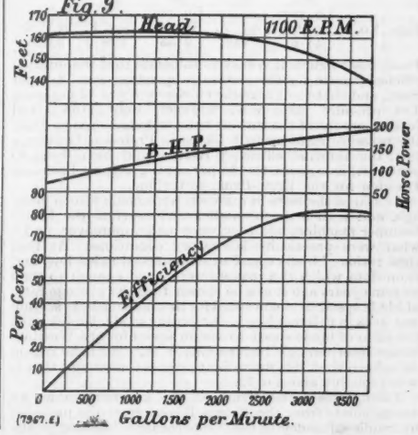
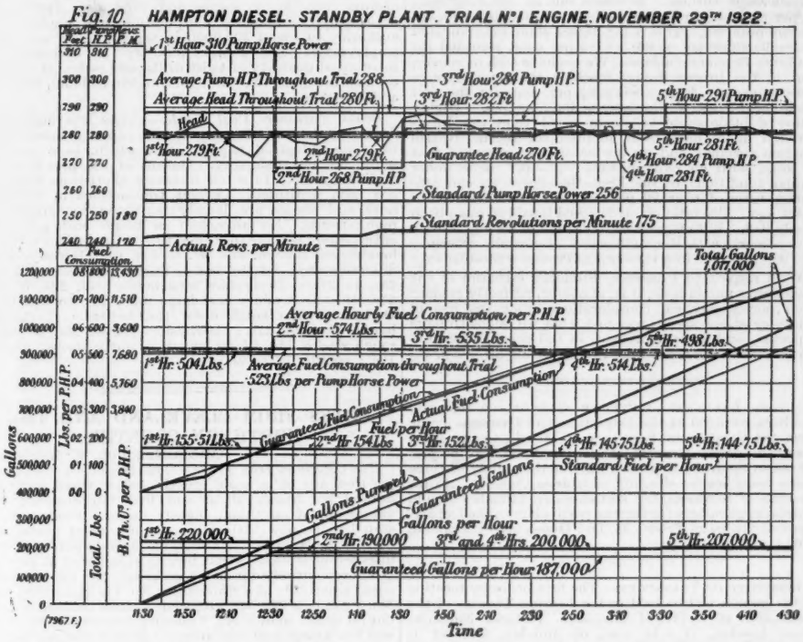


Fig. 10. HAMPTON DIESEL. STANDBY PLANT. TRIAL N°1 ENGINE. NOVEMBER 29TH 1922.



EDUCATION IN ENGINEERING.—The London County Council has issued an interesting pamphlet entitled "Engineering," giving particulars of all the polytechnics and institutes at which mechanical, electrical, motor and general engineering classes are given. The pamphlet can be obtained from the Education Officer's Department, County Hall, Westminster Bridge, S.E. 1.

NORTHAMPTON POLYTECHNIC INSTITUTE.—This institute, whose address is St. John-street, E.C., has issued in a separate booklet the information relating to the evening classes for the session 1923–24. The classes cover mechanical engineering, civil and structural engineering, aeronautics, pattern-making, moulding and numerous other trades, electrical engineering, &c. The session of the Institute begins in the week commencing the 24th inst. Enrolments start on the 17th inst.

"TEST OF AN ERSTE-BRUNNER BACK-PRESSURE STEAM TURBINE."

TO THE EDITOR OF ENGINEERING.

SIR,—I regret having used the expression "effective pressure" for gauge pressure, as this led you to a false conclusion. It is, however, not clear to me, how you could suppose this to stand for absolute pressure, as the turbine was for back pressure and the effective pressure in the outlet was given to be 7·3 lb. per square inch. An absolute pressure of 7·3 lb. per square inch would hardly be expected in the outlet of a back-pressure turbine (the total temperature in the outlet, given as 314 deg. F. in the first column, should read 324 deg. F.).

Your addendum (speaking of names, would not *correction* have been more suitable ?) in the issue of August 17 shows that, according to your own calculation, the "hydraulic" efficiency of the turbine tested by me is almost as high as the hydraulic efficiency of the Ljungström turbine at Walsall (80·3 per cent. against 81·3 per cent.). For the Ljungström turbine you arrived at this figure by assuming a dummy loss of 2·5 per cent.; in the Erste-Brunner machine there is no dummy loss, so I do not see it is fair to reduce the test figures to the "only fair basis of hydraulic efficiency," if, in doing so, you ameliorate the figures for the Ljungström by as much as 2½ per cent. I have more objections to your general remark, that hydraulic efficiency should be the only standard of comparison, but I shall not here digress on this subject.

Moreover, the so-called hydraulic efficiency includes losses by disc-friction and by leakage past the blades; for these losses the high-pressure part is mainly responsible so that, in the Ljungström tests the hydraulic efficiency of the high-pressure part only is considerably lower than the overall hydraulic efficiency. Taking into account that the Erste-Brunner machine is only 2,500 kw. and the Ljungström is 5,000 kw., it must be inferred from your own figuring, considered in the light of the above remarks, that the Erste-Brunner machine is considerably better than the high-pressure part of any other type on the market.

What the efficiency of 82 per cent. or 83 per cent. at coupling, obtained with this 2,500 kw. back-pressure turbine means, as compared to current commercial practice, may also be realised by the figures you quote in your issue of August 31 from the "Metrovic" unit in Dalmarnock Power Station. The *best part* of this turbine (15,000 kw.), according to your analysis, shows an "*indicated*" efficiency of 80 per cent. or 81 per cent.

From my above comments it will be clear to you that I regret you only published my table with *your* remarks, without any of the conclusions *I* drew from my tests, as your appreciation of the figures can hardly be called exact, your readers may still be interested in the comments giving the opinion of

Yours truly,
W. DRESDEN.

[It is quite true that in calculating the indicated hydraulic efficiencies of reaction turbines dummy losses are deducted. This is quite proper because they have nothing to do with the blading efficiency proper. Similarly, in calculating the hydraulic efficiency of impulse turbines, losses by leakage and disc friction are deducted. We are informed that these are specially low in the case of the Erste-Brunner machine, and to meet Professor Dresden's claim we are prepared accordingly to allow an extra 1 per cent. for these which would make its indicated hydraulic efficiency 81·3, or practically identical with that of the Walsall turbine. The "indicated hydraulic efficiency" provides unquestionably the only fair way of estimating the value of a novel type of turbine as it practically eliminates the size factor. The magnitude of the "parasitic" losses is in fact mainly a question of finance and not of type. Thus by adopting 20 stages between the stop valve pressure and atmospheric pressure disc friction would be reduced to ½ of its value with 5 stages, and diaphragm leakage to ½. The "indicated hydraulic efficiency," however, would be unaltered, but unsophisticated observers might conclude, from comparative tests of the two, that some important new principle had been discovered. On the main point we ask Professor Dresden to make the same calculation from the Brown Boveri tests that we have suggested to Professor Stodola. If he does this, he will find himself unable to reaffirm "that the Erste-Brunner machine is considerably better than the high-pressure part of any other type on the market."—ED. E.]

TO THE EDITOR OF ENGINEERING.

SIR,—The considerable interest which this novel type of turbine has raised throughout the Continent and partially in England, may justify the coming back to its performance. I had the opportunity of carrying out further tests on the same turbine as Professor Dresden and arrived to almost identical results, as is proved by the following abbreviated table:—

	Test Number. I.	IIa.	IIb.
Average load at coupling of dynamo, kw.	2,555	1,050	989
Absolute steam pressure behind regulating valve, lb. per square inch	192	127	130
Total temperature behind regulating valve, deg. F. ...	739	733	561
Absolute pressure at outlet	23·5	23·1	23·2
Steam consumption in lbs. per kw.-hour	19·0	27·1	28·3
Thermodynamical efficiency calculated with state behind regulating valve and work at coupling, per cent. ...	82·6	77·1	76·4

Concerning the question of best standard for comparing

the performance of turbines working under different conditions, I would propose the suggestion made in my book*, *i.e.*, to distinguish between the performance of the blading proper, without taking into account the outlet-loss, and between the thermodynamical efficiency of the indicated work, as is expressed by the equation :—

$$\eta_i = \frac{H_i}{H_o} = (1 + \rho)\,\eta_s - \zeta_a \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where H_i H_o are the indicated and the adiabatic heat drop, $1 + \rho$ the reheat factor, η_s the mean efficiency of the blading in one stage, ζ_a the outlet loss. The sum $\eta_i + \zeta_a$ can be called the "total" blading efficiency and is *already employed* by some Continental firms. If we pass to the effective work, we get :—

$$\eta_e = \eta_i - \zeta_r = (1 + \rho)\,\eta_s - \zeta_a - \zeta_r$$

and from this :

$$\eta_s = \frac{\eta_i + \zeta_a + \zeta_r}{(1 + \rho)} \quad . \quad . \quad . \quad (2)$$

where ζ_r means the friction loss (bearings, &c.). If I understand well, η_s means pretty much the same as the hydraulic efficiency ratio introduced by Mr. H. M. Martin, and gives the best standard of comparing the blade performance, if due consideration is given to the ratio of blade speed to steam speed employed. Unfortunately it cannot be determined without knowing the outlet and friction loss ζ_a ζ_r, so that generally, as in the case of the Erste-Brunner, we are constrained to be content with η_e or η_i. It is further advisable to calculate η_s or η_i with the steam conditions behind the regulating valve, as the throttling loss has nothing to do with blade efficiency. For the commercial appreciation of a given turbine, of course only the conditions before the turbine are a valid standard.

If we compare on this basis the Erste-Brunner turbine with the Interborough turbine, *i.e.*, with the high-pressure part of it, there comes out for the latter, in making use of an indirect indication of the wetness of the steam at the outlet, at a load of 26,153 kw. $\eta_i = 81$ per cent. As the superheat of the Erste-Brunner was higher, taking the correction tables of Baumann, which indicate a low raising of the efficiency at very high temperatures, I get $\eta_i = 83$ per cent. as against 84·2 per cent. for the Erste-Brunner in my tests (84.0 in those of Professor Dresden). An estimation of the reheat factors leads to 1·045 in both cases, and as far as we assume, the outlet losses to be not very different. We must conclude to the superiority of the Erste-Brunner.

This fact deserves attention when the difference of output is duly considered; at least 14,000 kw. for Interborough against 2,500 kw. for Erste-Brunner. This latter, moreover, offers peculiar scientific interest, as it is known indeed that the steam velocities has been very much lowered in it so that its designer can pretend to have anticipated the results of the nozzle-research committee of the Institution of Mechanical Engineers. I must confess that I have some doubts as to the statement that the velocity ratio "ϕ" will approach nearly unity when the velocity is reduced under 100 metres per second, and I should strongly recommend the verification of this law by eliminating all sources of suspicion which are still present in the experimental apparatus. Of course the very fine result of the Erste-Brunner can also have been obtained by a sufficient sum of "velocity squares" (Σu^2), by the reduction of skin friction in consequence of small size diameters, &c. The fact is that on the Continent the back-pressure piston steam engine had till now a marked predominance over the back-pressure steam turbine, and that since the Erste-Brunner they are on the same level. This will probably have a repercussion on the chemical industry where there are great quantities of heating steam. The plant in Nestomitz, where the turbine is installed, already works in parallel with an outside electrical power station, to which it furnishes power in conditions never attainable for an independent condensing turbine.

Yours faithfully,

PROFESSOR D. A. STODOLA.

Zürich, September 3, 1923.

[With respect to the foregoing letter from Professor Stodola we can only say that we totally disagree with his conclusion that a higher hydraulic efficiency was realised in the Erste-Brunner tests than with the Westinghouse Interborough turbine. The true comparative figures are that the "indicated" hydraulic efficiency of the Interborough turbine was at least 84 per cent., whilst that of the Erste-Brunner turbine as given by Professor Dresden was $\frac{84}{1{\cdot}045} = 80{\cdot}3$ per cent., or perhaps 81·5. We would also add quite definitely that this latter figure is habitually exceeded in current British commercial practice. Professor Stodola's conflicting result is due to the defective method of calculation used. Fortunately, data are available which suffice to show the superiority of the Westinghouse Interborough turbine without entering into the vexed question of superheat corrections or of supersaturation effects. Thus in 1908 Messrs. Brown Boveri and Co. published in the Z.V.D.I. particulars of tests made on a turbine of 1,000 kw. rating using such high superheats that the superheat was maintained on some of the tests up to the very exhaust pipe. Steam temperatures were determined at various points with very special care, electric thermometers being used, and as corresponding pressures were recorded, it was possible to determine the efficiency ratio of the intermediate section of the turbine, just as Professor Dresden has done for the Erste-Brunner machine. In that case he found an internal efficiency ratio of 84 per cent. which, taking his pressures as gauge pressures, corresponds to an hydraulic efficiency of 80·3 per cent., or, allowing for disc friction, perhaps 81·5 per cent. In trial No. 1 of the Brown Boveri machine the following figures were recorded, p_1 and t_1 denoting the absolute pressure and the temperature respectively at the beginning of the intermediate section, and p_2 and t_2 the corresponding pressure and temperature at the end of the section :—

	p_1	t_1	p_2	t_2	
	Lb. per		Lb. per		
Exp. No.	Sq. In.	Deg. F.	Sq. In.	Deg. F.	R.P.M.
1	44·6	442	9·53	228·2	3,320

From these figures it is easy to calculate that the internal efficiency ratio for the section in question was 78·5 per cent., and that the hydraulic efficiency η was 75 per cent. The pressure ratio was, however, only 4·68. Had further groups of the turbine been included so as to bring the pressure ratio up to 8·73, as in Professor Dresden's test, the internal efficiency ratio would have been 83 per cent., as against the 84 per cent. given by Professor Dresden for the Erste-Brunner turbine.

As stated the tests in question were made fifteen years ago, and with a much smaller turbine than the Erste-Brunner machine, and they were made, moreover, under what were practically laboratory conditions. At that time ratios of blade speed to steam speed ruled low, and from data which the makers were good enough to send us some years ago it can be shown that the average ratio of blade speed to steam speed for this intermediate section was 0·48 in this test No. 1. According to Mr. Hodgkinson the ratio of blade speed to steam speed for the Westinghouse Interborough turbine was 0·75. We have reason to believe that this figure is an over-estimate and that it was probably about 0·72.

Taking this latter figure as the less favourable, we can calculate from the Brown Boveri tests the probable hydraulic efficiency of the "superheated" section of the Interborough turbine. It comes out at the very least 84 per cent., as Professor Stodola will find if he makes the computation. This is far higher than the indicated hydraulic efficiency of 80·3–81·5 per cent. recorded for the Erste-Brunner machine. We ought to add, moreover, that in the Brown Boveri machine the tip clearances were unusually large, being 6¼ per cent. for the first group of blades of the intermediate section. Higher ratios of blade speed to steam speed than the Interborough figure have been adopted for recent British reaction turbines, and we are creditably informed that in tests, with an experimental "group," made under similar conditions to the Erste-Brunner tests, an efficiency ratio of over 90 per cent. was recorded a few years ago. The ratio of blade speed is said to have been nearly 0·9. With regard to hydraulic efficiency Martin always works with the "indicated" hydraulic efficiency and it is not therefore the same as Professor Stodula's η_s.

With respect to Professor Stodola's criticism of the Manchester nozzle tests, it is, of course, perfectly evident from purely physical considerations, that the rise of efficiency at low speeds was just what we ought to have expected, and it is, moreover, in full accord with experience with the nozzles used for metering air.—ED. E.]

* Dampf-und Gasturbinen V, edit. p. 207, formulae (2).

MOTOR LAUNCHES, GULF OF GUINEA.—A telegram has been received at the Department of Overseas Trade from the Commercial Secretary at Madrid to the effect that the Spanish Government invites tenders to be presented in Spain by September 28 for the supply of three motor launches for the Gulf of Guinea Colonies. Firms desirous of tendering for British-made launches should address applications for further particulars to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1

INSTITUTE OF TRANSPORT.—The first ordinary meeting of the session will be held in the Lecture Theatre of the Institution of Electrical Engineers, Victoria Embankment, London, at 5.30 p.m., on Monday, October 1, when Sir Joseph G. Broodbank will deliver his presidential address. At the same time and place, on Monday, November 5, the fourth annual general meeting will take place, at the conclusion of which a paper will be read by Mr. T. Salkield, on "A Transport Adventure in Persia," descriptive of a pioneer surveying expedition in connection with proposed trade routes between Quetta in Baluchistan and Meshed in Persia. Application for admission cards should be addressed to the Office of the Institute, 15, Savoy-street, W.C. 2. On Tuesday, October 16, at 5.30 p.m., in the same Lecture Theatre, Mr. Philip Burtt (hon. treasurer) will deliver a lecture on "The Institute Examination Scheme."

SOUTHERN INDIAN TIMBERS.—A Technical Paper (No. 234) issued by the Railway Board, Simla, consists of "Notes on the Identification of Timbers in Southern India," and is likely to prove useful to many engineers engaged in that country by drawing attention to the distinctive features of the more important timbers in use in engineering work. The notes in the paper are very clear, and will be made more lucid to those not wholly familiar with accepted terms, by reference to large scale key diagrams, while for the reproductions in colour of transverse magnified sections of 10 typical woods we have unqualified praise. They are excellently produced and bring out the several characteristics very plainly. A rather curious slip has been made with regard to magnification in the case of Fig. 2, but it is fairly obvious what is intended. The price of this publication is eight annas.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The recent downward movement of raw and semi-finished materials having failed to stimulate purchases, further reductions of a minor character are this week notified. Hematites have been marked down an average of 5*s.*, while forge and foundry iron are from 5*s.* to 7*s.* 6*d.* per ton cheaper. No further alteration, however, has been made in steel billet prices, which, according to leading manufacturers, are absolutely rock bottom, and allow little, if anything, for profit after meeting heavy working expenses. Revised official quotations are as follow: Hard basic steel billets, 10*l.* 10*s.*; soft basic steel billets, 8*l.* 10*s.*; West Coast hematites, 5*l.* 12*s.* 6*d.*; East Coast hematites, 5*l.*; Lincolnshire No. 3 foundry iron, 4*l.* 12*s.* 6*d.*; Lincolnshire forge, 4*l.* 10*s.*; Derbyshire No. 3 foundry, 4*l.* 12*s.* 6*d.*; Derbyshire forge, 4*l.* 10*s.*; bars, 12*l.*: sheets, 14*l.* to 15*l.* These reductions have already gone some little distance towards inducing consumers to take a more active interest in the market, though at the current rate of consumption there is no immediate prospect of output being enlarged. A certain measure of relief will accrue to the local staple industries from the reduction of municipal rates. Manufacturers consider this reduction long overdue, and declare that further pruning of municipal expenditure must occur before Sheffield is placed on a competitive basis with similar steel and machinery-producing centres in the country. Steel production is still on the down grade. The latest official returns for July show that the gross output of Sheffield and Rotherham, 61,000 tons, was nearly 40 per cent. less than that of the preceding month. Returns for August are expected to show a further contraction. Engineering inquiries are fairly satisfactory, despite the slump on shipbuilding account. Heavy machinery is wanted for Canada. Inquiries are in circulation on Colonial account for power station plant and electrical and brick-making machinery. One of the South Yorkshire colliery groups proposes to spend three-quarters of a million pounds in opening out lower seams and otherwise developing existing pits. Sheffield Corporation has applied for authority to spend 300,000*l.* in the provision of winter employment. The motor industry is absorbing a substantial quantity of twist drills, and orders of a light tonnage are under execution for Sweden, Holland, Norway and Australia.

South Yorkshire Coal Trade.—Prices are uniformly firm, though this is due more to the export demand than to home industrial requirements, which, in a general sense, are unsatisfactory. Output at the pits is on a declining scale. In a few instances short-time working has been instituted. Current transactions in cobbles, nuts and slacks are largely restricted to immediate requirements. No alteration in house coal prices is anticipated for another month. Quotations :—Best handpicked branch, 30*s.* 6*d.* to 32*s.* 6*d.*; Barnsley best Silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights 25*s.* to 27*s.*; Derbyshire best house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Transactions in Cleveland pig-iron are on a scale greatly below what could be desired, but demand shows some little improvement, and values are, if anything, slightly firmer. Production is stated to be now little in excess of current needs, but makers have rather considerable accumulation of undisposed-of stocks. What buying is reported at present is almost entirely for home purposes, the export trade being practically at a standstill. No. 1 is quite 103*s.* 6*s.*; No. 3 g.m.b. is 97*s.* 6*d.*, with some makers inclined to hold out for rather more; No. 4 foundry is offered at 92*s.* 6*d.*; and No. 4 forge is on sale at 90*s.*—all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—Values of East Coast hematite are rather more than maintained, and home demand is improving slightly, but as yet, there seems to be no change for the better in foreign trade. It is some satisfaction to find hematite selling once more at above the price of Cleveland No. 3 quality, though it would seem as though some considerable time must elapse before the usual 8*s.* margin of pre-war normal days can be looked for. Mixed Nos. of hematite are 99*s.*, both for home use and for shipment overseas.

Foreign Ore.—Transactions in imported ore are hardly heard of, and market rates are still nominally based on 23*s.* c.i.f. Tees for best rubio.

Blast-Furnace Coke.—There is continued scarcity of Durham blast-furnace coke, though local users experience much less difficulty in securing supplies than they did a little while ago. Good average qualities are quoted 40*s.* to 41*s.* delivered to consumers' works.

Manufactured Iron and Steel.—Whilst new business in finished iron and steel matures slowly, better inquiries are circulating of some descriptions of material, and hope is entertained that orders which have been held up for some time will shortly be released. Manufacturers are keen to secure orders and would possibly enter into contracts at a little below the recognised market quotations :—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel ship, bridge and tank plates,

angles, joists and heavy steel rails, each 9*l.* 10*s.*; fish plates, 12*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 19*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade producers continue extremely quiet, and no change of any kind has taken place in the conditions this week. The actual demand is of small dimensions and inquiries are far from satisfactory, even foreign buyers are not asking for more than very limited quantities of material over all. The placing of orders for two liners for the P. and O. Steam Navigation Company, Limited, will not relieve the position to any great extent, but it will always help a little, as a fair amount of material will be required, and as the demand for shipbuilding material has been so poor of late. Like other vessels now on order, little can be done with these boats until the lock-out of boilermakers is over. Black sheet makers are not busy despite the better demand now prevailing for galvanised sheets for export. Buyers all round are acting with caution for fear of being too heavily covered should prices ease off, but there is little fear of that so long as makers think as at present. The current quotations are as follow:—Boiler plates, 13*l.* per ton: ship plates, 10*l.* per ton; sections, 9*l.* 15*s.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The state of trade at the bar iron works in the West of Scotland is still very poor and buyers are not placing orders of any importance. Similar conditions prevail in the re-rolled steel branch of the industry. Prices remain unchanged, with "Crown" bars called 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—No change can be reported in the Scottish pig-iron trade and quietness is very general at the works. The demand on export account does not amount to a heavy tonnage, as may be seen from the weekly returns. Prices have an easier tendency, and the following may be taken as the current figures:—Hematite, 5*l.* 5*s.* per ton, delivered at the steel works: foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The export of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, September 8, amounted to 814 tons. Of the total 728 tons went overseas and 86 tons went coastwise. For the corresponding week last year the figures were 522 tons foreign and 129 tons coastwise, making a total shipment of 651 tons.

Clyde Shipbuilding.—The shipbuilding order already referred was placed last week by the Peninsular and Oriental Steam Navigation Company, Limited, with Messrs. Barclay, Curle and Co., Limited, Whiteinch. It is to build and engine two liners, each of 15,000 tons deadweight, and to have engines of 11,000 i.h.p.

PARCELS POST TO PERU.—In June, 1922, the Peruvian Government issued regulations requiring all goods sent to Peru by parcels post to be accompanied by a Consular invoice. It has, however, been possible to obtain possession of goods sent by parcels post, when no Consular invoice has been obtained, by paying the Consular fee which would have been levied for legalising the invoice. H.M. Consul at Callao now reports that from October 1 a fine of 25 per cent. of the value of the goods will be imposed for omitting the Consular invoice, even if one is obtained after the parcel has been despatched.

CARBURETTOR ADJUSTMENT ACCORDING TO EXHAUST ANALYSIS.—As a result of the analyses of exhaust gases in actual service, of motor lorries of the United States Government fuel yard at Washington, an increase of mileage of 22 per cent. has been obtained from the machines following adjustments made to the carburettors. As a rule carburettors are found to be adjusted for too rich a mixture, gauged by the proportion of CO_2 in the exhaust gases while the machine is at work, and it is suggested that greater attention should be paid to sampling the exhaust while the machines are actually at work, and making the necessary analysis in order to secure more economical operation. As the improvement is not maintained permanently, the machines should be checked every two months or so, or examined if their mileage and consumption show signs of falling off.

MANCHESTER ASSOCIATION OF ENGINEERS.—On Thursday, the 6th inst., upwards of 150 members of this association accompanied by their president (Mr. Cecil Bentham), visited the extensive wire rolling mills at Clayton, of Messrs. Richard Johnson and Nephew, Limited. These works which employ some 1,200 hands have been in existence since 1854, since when they have been transformed four or five times. The last transformation is the change over from steam to electricity; and to-day this is the motive power for the whole works. The latest addition is the continuous wire-rod rolling mill, driven by three alternating current, 6,600-volt motors of 2,750 i.h.p., 750 i.h.p. and 750 i.h.p., respectively, direct from the Manchester Corporation mains. The mill rolls two billets at a time, 2 in. square, 28 ft. long, weighing 364 lb. each, in any quality of steel from "dead soft" to 0·80 carbon; and each billet is reduced to a No. 5 rod in 1 minute. This mill is unique, as it can roll two different sizes of rods out of the same stock at the same time. The first continuous mill was run in the early 'sixties, and the second, built in 1866, is still running.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—With the possibility of a prolonged strike of American miners off and the Greco-Italian situation easier the hopes of a material improvement in the coal trade have disappeared. In fact, buyers are holding off and keeping their requirements within the narrowest margin practicable. Collieries generally are well covered on contract account, but even so the quantity of coal offered on the market from day to day is in excess of buyers' requirements. In the circumstances prices generally are weaker with a wide disparity for similar classes of coal, according to the varying circumstances of sellers. Spot lots can be secured at 1*s.* per ton below the price asked for prompt loading and for shipment a couple of weeks ahead, neither sellers or buyers are anxious to operate as they generally prefer to run the risk of the market. The policy of most shippers now is to start boats loading with contract coals and to complete on the market. The Dutch State Railways have contracted for 10,000 tons of Monmouthshire large coal on the basis of about 26*s.* 6*d.* f.o.b., while the French State Railways are inquiring for 30,000 tons of large and small. Best Admiralty large coals are available from 28*s.* 3*d.* to 30*s.* with seconds about 1*s.* less and Monmouthshires from 27*s.* to 29*s.* Dry large coals are relatively well placed and steady at 27*s.* 6*d.* to 30*s.* In regard to smalls, coking sorts are scarce and firm at 22*s.* 6*d.* to 25*s.*, according to quality, but best bunkers are readily obtainable round 20*s.* with ordinaries from 17*s.* to 18*s.* and inferiors as low as 14*s.* Coke is also a quiet market at 40*s.* to 50*s.* for export with patent fuel too inactive round 32*s.* Exports of coal as cargo last week amounted to 578,650 tons, compared with 553,240 tons in the previous week and 568,800 tons a fortnight ago. These returns prove that generally the collieries must be well booked up under contract for shipments continued on a good scale, and last week's total was at the rate of nearly 29,000,000 tons per annum, compared with just under 30,000,000 tons a year in the record-breaking year of 1913. Of last week's exports France took 221,500 tons, Italy 98,450 tons, South America 64,170 tons, Spain 34,770 tons, Portugal 15,950 tons, Greece 6,780 tons, British coaling depots 39,100 tons, United States 4,540 tons, Canada 7,290 tons, Belgium 16,370 tons, Holland 16,880 tons, Germany 10,980 tons, and other countries 41,820 tons. Of the shipments, Cardiff contributed 324,690 tons, Newport 122,380 tons, Swansea 66,270 tons, Port Talbot 51,070 tons and Llanelly 14,240 tons.

Iron and Steel.—A meeting of the Tinplate Prices Stabilisation Committee was held at Swansea yesterday, when it was decided to make no change in the prices of tin plate or tin-plate bars, which therefore remain at 23*s.* 1½*d.* basis I.C. f.o.b. minimum for tin plates and 9*l.* 2*s.* 6*d.* per ton for bars, less 7*s.* 6*d.* rebate to the tin-works in the scheme, for the next three months. Exports of iron and steel goods last week showed a considerable reduction. Shipments of tin plates and terne plates were reduced from 8,208 tons to 4,448 tons, and backplates and sheets from 3,256 tons to 2,645 tons, but those of galvanised sheets were increased from 614 tons to 1,328 tons, while other iron and steel goods were decreased from 8,378 tons to 6,061 tons.

THE BRUSH-DELAS AIR EJECTORS.—The Brush Electrical Engineering Company, Limited, of Loughborough, have acquired a licence for the manufacture of the "Delas" air ejector for creating and maintaining the vacuum in condensers without the use of mechanical air-pumps. Like other apparatus of the kind, it consists of two steam jets working in series, its special feature being the water-cooling of the diffuser. It is claimed that this provision not only increases the efficiency of the apparatus, but also renders it stable in its action.

INCREASE IN PANAMA CANAL TRAFFIC.—The fiscal year ending June 30, 1923, showed a considerable increase in commercial traffic through the Panama Canal, the number of vessels passing being more than 1,200 above the figure for the previous year and well over 1,000 more than for 1921. The amount taken in tolls was 17,508,199 dols., compared with 11,197,832 dols. in the previous year. The month of May this year, with 419 passages, surpassed all previous records, the best monthly figure as regards transit having been December, 1920, with only 260. The tolls for May amounted to 1,972,216 dols. compared with the previous best of 1,105,536 dols. in March, 1921.

RAMSAY MEMORIAL DEPARTMENT OF CHEMICAL ENGINEERING.—The work of the Ramsay Memorial Department of Chemical Engineering at University College, London, will begin in October. This department has been instituted with the object of enabling young graduates in chemistry and engineering, who have already obtained a good training in the fundamental sciences of chemistry, physics and mathematics, to direct their studies and investigations towards the application of the principles of physical chemistry to the scientific design and operation of the apparatus and processes of chemical industry in general. Mr. E. C. Williams, M.Sc. of the University of Manchester, has been appointed professor in charge of the department. The University College Committee will shortly appoint an Assistant Lecturer in the department. The Assistant Lecturer must have had an engineering training. The commencing salary will be either 350*l.* or 400*l.* according to the training and experience of the man appointed.

NOTICES OF MEETINGS.

THE INSTITUTION OF THE RUBBER INDUSTRY, LONDON SECTION.—Monday, September 17, at 8 p.m., at the Engineers' Club, Coventry-street, Piccadilly, W., Mr. Evan J. Edwards will read a paper, entitled "Rubber Floors and Rubber Roadways." Chairman, Mr. Francis Hooper, F.R.I.B.A.

THE IRON AND STEEL INSTITUTE.—Monday and Tuesday, September 17 and 18, at 9.30 a.m. Autumn Meeting at the Chamber of Commerce, Milan. Papers to be read and discussed: "Alloys in the Ternary System Iron-Chromium-Carbon," by Mr. C. R. Austin; "The Iron-Iron Carbide Equilibrium in Dry Hydrogen at 950 Deg. C.," by Mr. E. D. Campbell, Mr. W. L. Fink and Mr. J. F. Ross; "The Relative Efficiency of Dry and of Moist Hydrogen on the Decarburisation of Steel at 950 Deg. C., and the Effect of Hydrogen on the Phosphorus Content," by Mr. E. D. Campbell, Mr. J. F. Ross and Mr. W. L. Fink; "A Note on Coarse Corrugation in Mild Steel Sheets," by Mr. C. A. Edwards and Mr. L. B. Pfeil; "The Iron and Steel Industry of Italy," by Mr. G. E. Falck; "The Complex Action of Manganese and of other So-called Deoxidising Agents in the Manufacture of Steel," by Mr. F. Giolliti; "The Change Points in Some Nickel-Chromium Steels," by Mr. W. T. Griffiths; "The Influence of Nickel and Chromium upon the Solubility of Steel (in Relation to Corrosion)," by Mr. W. H. Hatfield; "The Iron Ore Mines of Nurra (Sardinia)," by Mr. Cesare Martelli and Mr. Tito Sotgia; "The Morphology of Pro-Eutectoid Cementite," by Mr. A. Portevin; "The Corrosion Cracking of Steel under the Influence of Internal Stresses," by Mr. A. Portevin; "The Effect of Low Temperature Annealing on Some Mechanical Properties of Cold Drawn Steels," by Mr. S. H. Rees; "Theory and Practice of Steel Refining," by Mr. H. Styri; "The Manufacture of Heavy Steel Castings from Small Converters," by Mr. C. Vanzetti; "Grain Growth in Iron and Steel," by Mr. H. C. Wang. Wednesday, September 19, to Tuesday, October 2: Visits to works and excursions to various places of interest.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday, September 20, at 7 p.m., at the Engineers' Club, Coventry-street, W. 1. "Heavy Tonnage Handling on Railways of the United States," by Mr. R. P. C. Sanderson, Member of Council.

SHAFTS FOR MARINE STEAM ENGINES.—The Board of Trade has issued a pamphlet containing standard conditions and rules for the shafts of marine steam engines. These conditions and rules were framed by a conference constituted of representatives of the Board of Trade, Lloyd's Register of Shipping, the British Corporation for the Survey and Registry of Shipping, and the Bureau Veritas, and, as in the case of the standard conditions for cylindrical marine boilers published in 1920, and water tube marine boilers published in 1923, were based to a very large extent upon the recommendations of the British Marine Engineering Design and Construction Committee. The Board of Trade is indebted to this Committee for the very valuable work which they have carried out and which is now completed. It is hoped that the results of this work will enable an appreciable advance to be made in the direction of standardisation. The pamphlet containing the Standard Conditions is published by H.M. Stationery Office, price 1*d.* net.

PRIVACY IN TELEPHONY.—A booklet relating to an attachment which can easily be placed in position on, or removed from, an ordinary desk telephone for the purpose of rendering the conversation inaudible to persons in the same room as the user has reached us from the British Hush-a-Phone Company, Limited, 19, Berkeley-street, London, W.1. The attachment consists of an aluminium box, finished in black enamel, with closed ends and an opening in the centre of each side. One of these openings fits on to the telephone transmitter and the other, which is opposite to the first, is in the form of a mouthpiece into which the user speaks. The ends of the box are closed with pads of sound absorbing, material and we are given to understand that the use of the appliance not only prevents the conversation from being heard by a person sitting only a few feet from the speaker, but by excluding extraneous sounds from the transmitter also has the effect of improving the quality of the speech reception at the distant end of the line.

THE COAL PROBLEM IN CANADA.—Recent American coal strikes have painfully impressed Canadians with the danger of having to rely upon a single foreign country, albeit a friendly one, for one of the prime necessities of life and industry. A further complication is the prejudice of the people of Central Canada in favour of United States anthracite arising from the long use of this fuel. The Dominion Fuel Board proposes to enquire into the question of a wider range of utilisation of the coals of British Columbia, Alberta and the Maritime Provinces as well as the peat deposits, which are situated strategically in the acute fuel area. These coals are affected mainly by the problem of transport costs. Peat, it is thought, could be recommended for domestic furnaces during the spring and autumn, but not during the winter months. The most likely source of supply, beyond the border of Canada and outside the United States, is undoubtedly South Wales. Welsh anthracite is of a higher grade than Pennsylvanian anthracite. It was imported into several Canadian cities during the past winter, but according to the Dominion Fuel Board it should be sized and separated out.

DIESEL CENTRIFUGAL PUMPING PLANT FOR THE METROPOLITAN WATER BOARD.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER.

(*For Description see Page* 332.)

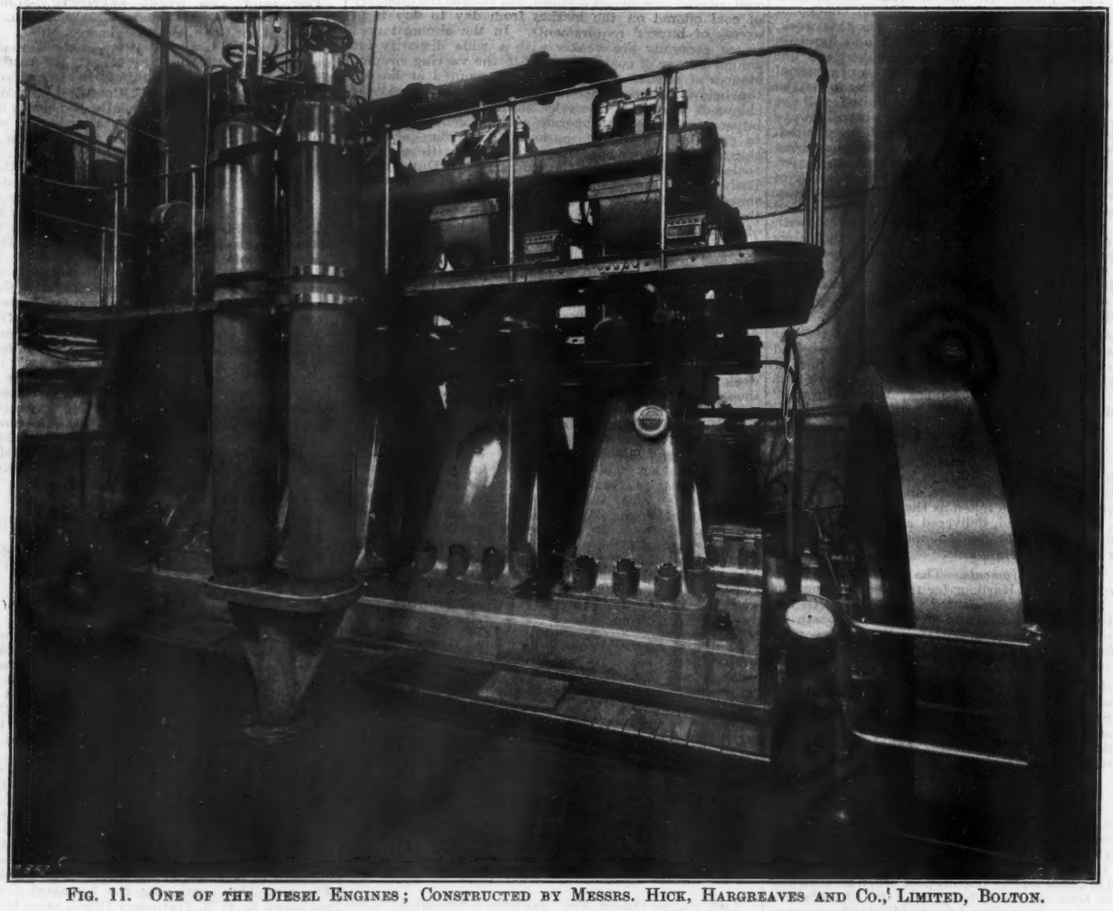


FIG. 11. ONE OF THE DIESEL ENGINES; CONSTRUCTED BY MESSRS. HICK, HARGREAVES AND CO., LIMITED, BOLTON.

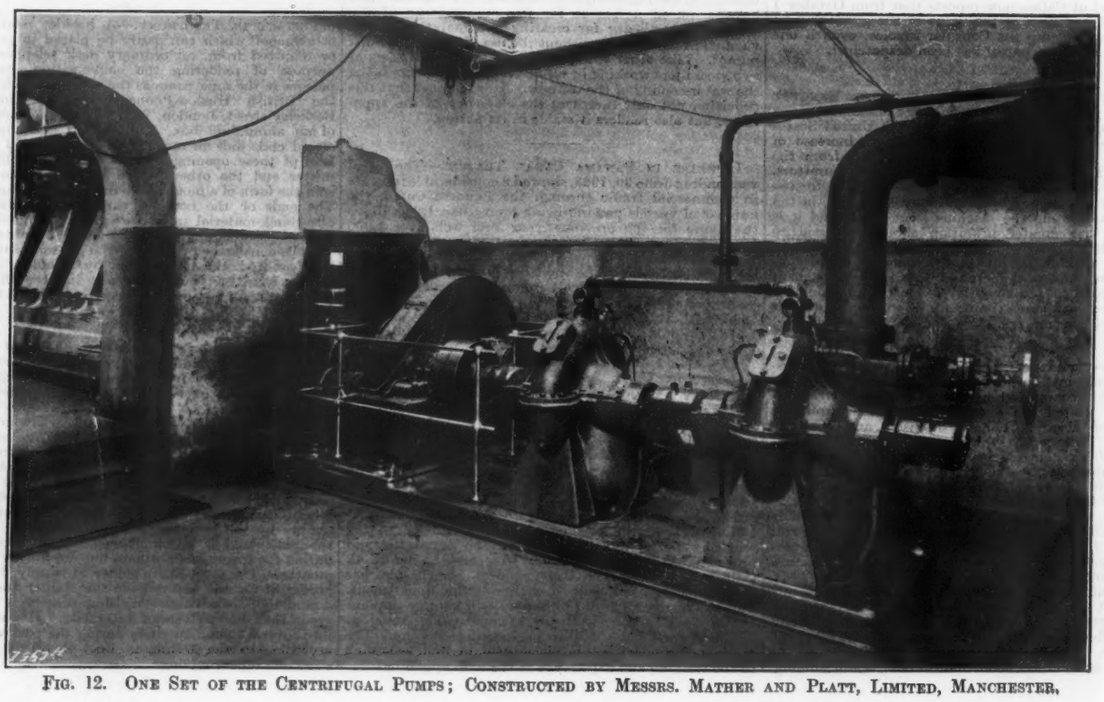


FIG. 12. ONE SET OF THE CENTRIFUGAL PUMPS; CONSTRUCTED BY MESSRS. MATHER AND PLATT, LIMITED, MANCHESTER.

DIESEL CENTRIFUGAL PUMPING PLANT AT HAMPTON; METROPOLITAN WATER BOARD.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER.

(*For Description, see Page* 332.)

Fig. 1.

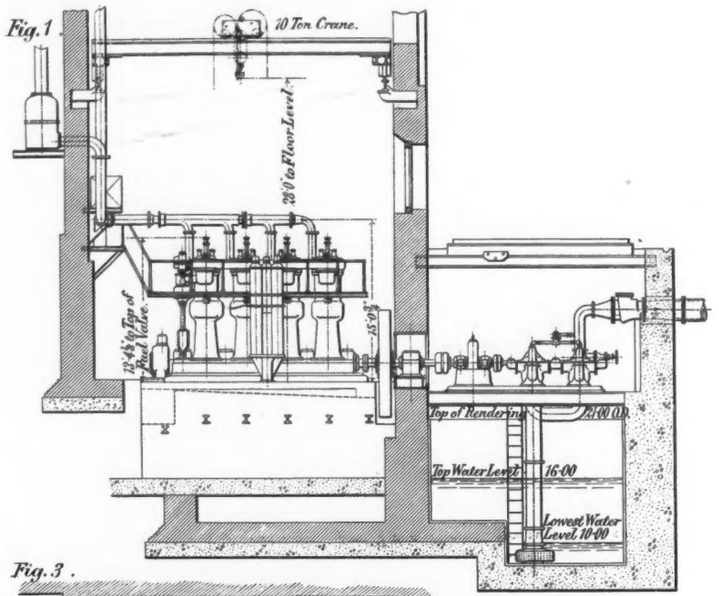


Fig. 2.

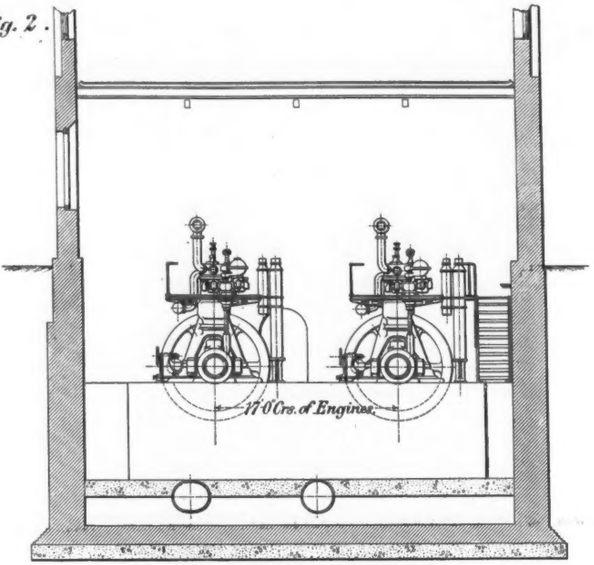


Fig. 3.

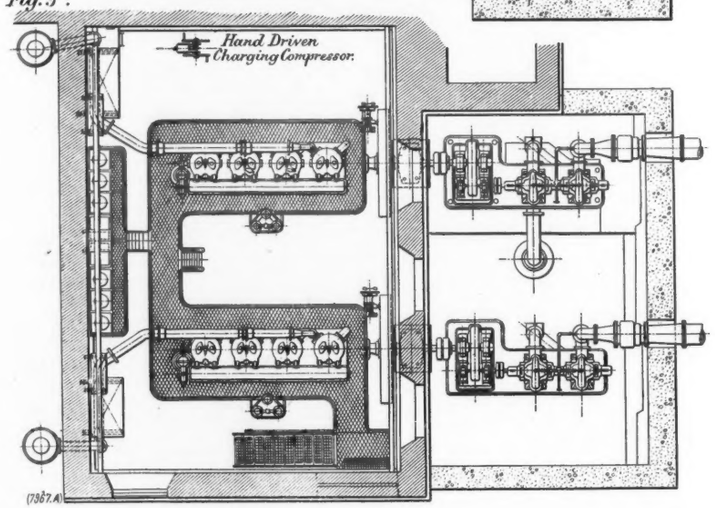


Fig. 4.

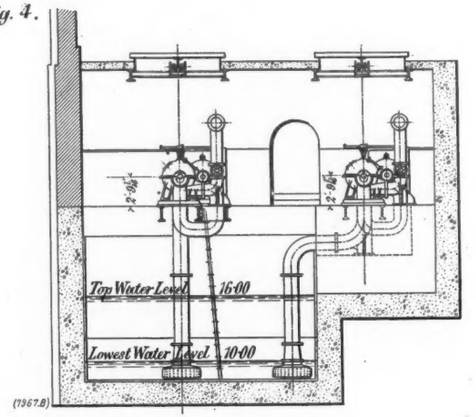


Fig. 5.

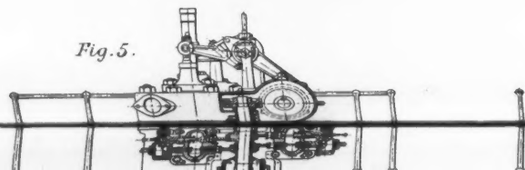


Fig. 6.

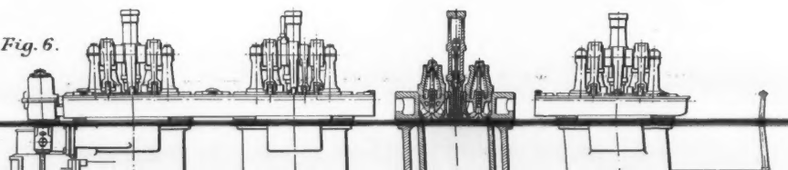


Fig. 5.

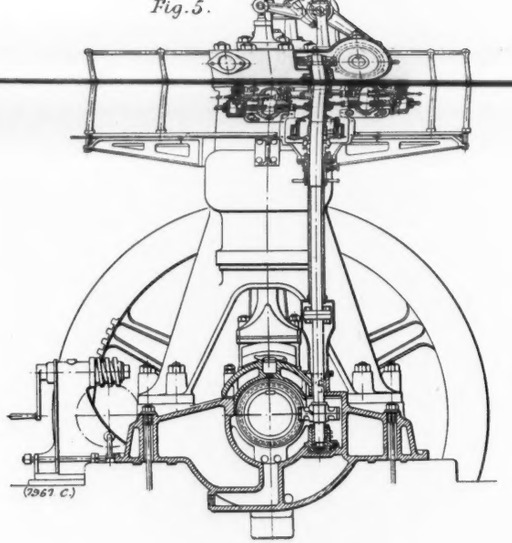


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Fig. 6.

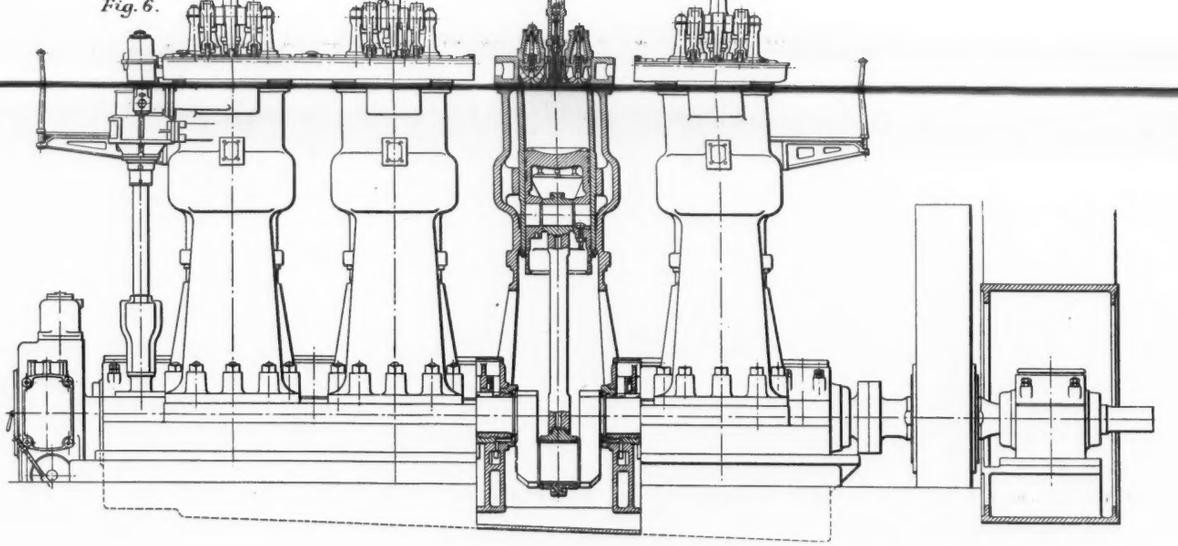
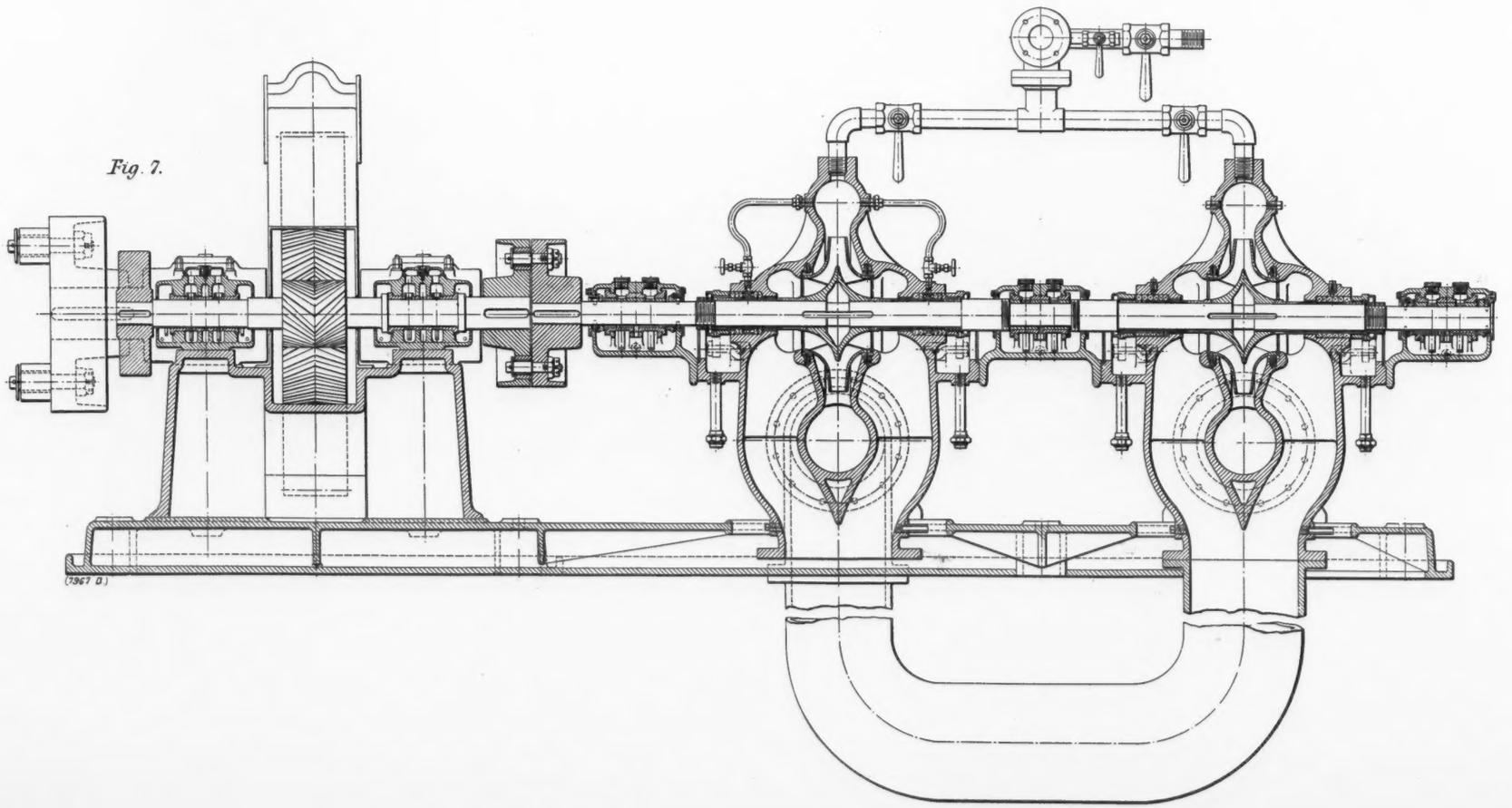


Fig. 7.



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CONTENTS.

	PAGE
Reciprocal Load Deflection Relationships for Structures (*Illus.*)	321
The Institution of Naval Architects in Holland...	322
Sanitation in India	324
The Shipping, Engineering and Machinery Exhibition at Olympia (*Illus.*)	326
Industrial Notes	331
Diesel Centrifugal Pumping Plant at Hampton; Metropolitan Water Board (*Illus.*)	332
Letters to the Editor.—Test of an Erste-Brunner Back Pressure Steam Turbine	333
Notes from South Yorkshire	334
Notes from Cleveland and the Northern Counties	334
Notes from the North	335
Notes from the South-West	335
Notices of Meetings	335
Atoms and Energy	337
The Conductivity of Building Materials	338
Patent Statutes	339
The British Association	339
The Institute of Metals	340
The United States Aircraft Carrier "Langley" (*Illus.*)	342
Steam Turbines for Marine Propulsion in Holland (*Illus.*)	344
The Effect of Small Quantities of Nickel upon High-Grade Bearing Metals (*Illus.*)	347
The Behaviour of Metals under Compressive Stresses (*Illus.*)	349
The Effects of Oxygen on Copper (*Illus.*)	351

Two-Page Plate.—DIESEL CENTRIFUGAL PUMPING PLANT AT HAMPTON; METROPOLITAN WATER BOARD.

ENGINEERING.

FRIDAY, SEPTEMBER 14, 1923.

ATOMS AND ENERGY.

PRESIDENTIAL addresses to the British Association, however intrinsically or potentially important the subject-matter, do not now-a-days excite so universal and intense an interest as they did on occasion, two or three generations ago, when for example Tyndall's famous Belfast address led to that audacious orator being threatened with personal violence. The innate curiosity of certain individuals is as marked as ever, but the extraordinary discoveries of the past thirty years, which Sir Ernest Rutherford discussed at Liverpool last Wednesday, appeal to a much more restricted audience than did some of the great discoveries of the Victorian era. The establishment of the truth that the world was not created in 4,004 B.C., and of the fact of evolution, cut across the most cherished convictions of our grandfathers and awakened emotions which the doctrine of relativity, though quite as sharply in conflict with time-honoured beliefs, failed to arouse. The one was accordingly but a seven days' wonder, whilst much of the scientific work of the great Victorian thinkers excited an active animosity, extending over many decades, a feeling which it would seem, from Bills recently promoted in certain States of the American Union, still persists.

Nevertheless, though advances in science no longer provide the masses with a conversational or controversial topic, it is a very wonderful world to which Sir Ernest introduces us. Of late years our main discoveries have centred round both the unimaginably minute, and the incomprehensibly great. On the one hand, we have succeeded in penetrating within the confines of the atoms, the extreme dimensions of which are such that some 100,000,000 placed side by side would barely span 1 in. and on the other hand we have succeeded in determining celestial distances reckoned in scores of light years, and even in measuring the diameters of certain fixed stars, in spite of their inconceivable remoteness.

Curiously enough, it seems probable that the study of these colossal fixed stars may provide us with valuable hints as to the structure and properties of the atomic microcosm. Knowledge of these may quite conceivably result in highly important practical applications, though, of course, the pursuit of science constitutes a legitimate end in itself, irrespective of the fact, that it frequently has as a collateral result, a betterment of the amenities of existence.

To Clerk Maxwell the atoms were ultimate particles, persistent and unchanged from an unlimited past. The researches of the last thirty years, in which this year's president has played one of the major parts, have shown us on the contrary, that each atom is in general a highly complex organisation. Its centre is occupied by a nucleus having a volume, small even when compared with that occupied by an electron, but in this minute nucleus practically the whole mass of the atom is concentrated. This nucleus surrounds itself with a guard or screen of electrons which, in general, shield it so effectively, that the nuclei of the heavier atoms almost attain to the status of the gods of Lucretius, so that to them no disturbance from the exterior "can mount to mar, Their sacred everlasting calm." Units of the guard may temporarily be ravished away, but in terrestrial conditions, at any rate, the vacant place is quickly filled by the impressment of the first vagrant electron encountered. The nuclei of the lighter atoms are less well protected, but even they, on the principle of diamond cut diamond, can be attacked effectively, only by fellow nuclei, such as the α particles from radium C.

These positively charged particles pass through the electron screen, and the nucleus must act as its own defender. In most cases it succeeds in deflecting and repulsing the intruder without suffering injury, but in the case of some of the lighter atoms, the blow is so shrewd as to sever the nucleus struck and to cause the expulsion of one of its component parts. This, in at least some cases, is ejected from the atomic system, with an energy exceeding that of the projectile striking it. In such cases, this projectile has, as it were, exploded a magazine in the nuclear citadel.

These extraordinary experiments raise the question as to whether it will ever be feasible to conduct the operation in question on a practical scale, and thus render the atomic stores of energy available for the production of power. As matters stand, however, the gap between these experiments and their practical exploitation, is far wider than that between the attraction of rubbed amber for light objects, and the electric generator of to-day. Some 2,000 years were needed to bridge this gap, but thanks to the technical developments, for which Sir Ernest expressed the indebtedness of science to industry, matters move faster to-day, and should the chasm be bridgeable at all, it should be spanned within a much more reasonable interval of time. The immediate prospect, it must be confessed, is far from bright. But one α particle in a million succeeds in tapping the energy stored in the atoms of aluminium. It is possible, therefore, that these stores may prove for ever nearly as inaccessible as minerals in the moon.

The Aesopean fox declared the grapes to be sour when he could not reach them, but we would be far from suggesting that similar motives actuated Sir Ernest, when he indicated the possibility that these stores of atomic energy had been vastly overestimated. The commoner atoms if not existent unchanged from an indefinite past, as Maxwell claimed, are at least extraordinarily stable in terrestrial conditions. This fact suggests that a great deal of energy was liberated at the time of their formation, and at least an equal amount must accordingly be required to disrupt them. It may well be, therefore, that there would be no net gain of energy by this latter operation. Under terrestrial conditions there is, of course, a net gain in the disruption of the radioactive atoms, but Sir Ernest suggests that these may be mere survivals of atoms which were originally of low stability, whilst the commoner atoms are of very high stability and may require a greater energy to disrupt them than would be set free in the process. The point cannot of course be settled by *a priori* arguments, but must be a matter for experiment and observation. Chemistry, it will be remembered, has made us acquainted with compounds such as acetylene, the formation of which at high temperatures is accompanied by a liberation of energy, whilst at low temperatures energy is set free by its dissociation. An analogy to this would seem to be afforded by the radioactive elements. In fact, were it permissible, to

assume that radium, its emanation, and helium, possessed at all temperatures the specific heats associated with monatomic molecules in normal conditions, it is easy to see that at a sufficiently high temperature there would be a tendency for an α particle to combine with an atom of niton to form a radium atom. On the assumption of normal specific heats, the combined total heat of the separate atoms of helium and niton, at any stated temperature, would be twice as great as the total heat of the atom of radium formed by their combination. Hence, large as is the energy liberated in terrestrial conditions by the disruption of radium, it is only a question of raising the temperature sufficiently to reach a point at which energy would be set free by a reversal of the process.

Bohr's theory of the atomic system is so popular and so successful in unifying phenomena, that it is well that Sir Ernest drew attention to certain of its limitations and drawbacks. It is one thing to have a formula, by which we can calculate and predict, and quite another to have a satisfactory mental picture of the processes at work. This was one of the strongest objections to the activities of the "energetic" school of physical chemists, which loomed so large thirty years ago. They expressed themselves as satisfied with equations and rejected the atomic theory as superfluous. To-day this school is wholly discredited, and successful as quantum mechanics has proved in the discussion of spectra, we still want to know why it is that certain orbits only are stable in atomic systems, and why no radiation occurs when electrons revolve in these. At present we have to accept these merely as ultimate facts of observation, much as was the case with Newtonian gravitation.

In a former address to the British Association, the late Sir Frederick Bramwell drew attention to the practical importance of what he called the "next to nothing." Thus an insignificant percentage of phosphorus ruins steel, mere traces of certain gases poison catalysts, and as Osborne Reynolds pointed out, an infinitesimal film of oil on water prevents it being flung into waves by the wind. A striking instance of the importance of these "next to nothings" is afforded by the fact that there appears good reason for believing that the solution of the outstanding mystery of how the sun's heat is maintained is to be found in the circumstance that the atomic weight of helium is 4 instead of 4·0288. Apparently in the sun and fixed stars atoms of hydrogen are being associated in groups of four to form atoms of helium, and in this process energy is given out, which is equal to twice the kinetic energy which would be represented by the loss of mass if it travelled at the velocity of light. This is so enormous that the energy released in forming 1 lb. of helium would, Sir Ernest said, be equal to that liberated by burning 8,000 tons of coal. In view of this fact, it is a happy coincidence that helium was first discovered in the sun, and named after its locus of origin.

In the concluding portion of his address, Sir Ernest seemed to deprecate the importance to science of the first-class intellect. "We cannot," he said, "invoke the aid of supermen." As a matter of fact we can, but like Hotspur's spirits, will they come when called? This is where the real difficulty lies. No amount of education or organisation can ensure a Newton, a Clerk Maxwell, or a Faraday, but unless such supermen do appear progress is slow. Co-operative effort is, in fact, ever parasitic on the thought of individual men of very special ability. In the commercial world the co-operative movement has founded no new manufacture, nor originated any improvement in the matter of distribution. It has merely followed and copied ideas originated elsewhere.

The average scientific man is just as dependent on the superman for the supply of ideas as is the co-operative store. It would take in fact just about as many average B.Sc.'s to replace a Faraday as of average B.A.'s to replace a Shakespeare. Magnificent team work has been accomplished at the Cavendish Laboratory, but we doubt if as much would have been done, had some of the other candidates for the position vacated by the late Lord Rayleigh been appointed instead of the youthful Thomson.

THE CONDUCTIVITY OF BUILDING MATERIALS.

THE rate at which walls, floors, ceilings and their coverings transmit heat does not depend only on what is known as their true conductivity, that is to say, the rate of transmission under unit difference of temperature between their faces. In practice it is also affected by unsteady variations of the temperature difference (such, for instance, as may occur if one face is suddenly but not steadily heated), by heat lost by conduction through edges, by radiation, and by convection. These factors are eminently difficult to standardise, and for the purpose of comparing different materials accurate determinations of the true conductivity may be of considerable practical value. The Building Research Board has accordingly published a report* on experiments on the subject made for them at the National Physical Laboratory by Dr. Ezer Griffiths, with an introduction by Mr. H. O. Weller, Director of Building Research. These experiments deal with the true conductivity, measured under a steady flow of heat, and in appendices an account is given of work done in Norway, Sweden and Germany, in which results are given for measurements of transmission of heat through all causes.

Though the report is unsigned, the figures are those of Dr. Griffiths, and the results may therefore be accepted as correct. Good sense suggests that it is usually wiser in considering any piece of work to pay more attention to what it does contain than to what it does not, and though any fair account of this report must make some reference to the methods adopted and the description that is given of them, the chief interest lies in the actual results. These are given alternatively as the heat in British or C.G.S. units which flows through unit area and thickness of the material in unit time under a steady temperature difference of 1 deg. F. or C.; in the case of composite walls the figure is given for the entire thickness. Taking British units for convenience, it is to be remembered that the conductivity of still air is 0·14 B.Th.U. per square foot per hour for 1 in. thickness and 1 deg. F. temperature difference. So far as materials are known at present, this is the asymptotic limit of their lowest conductivity. At the very end of some experiments that Dr. Griffiths made for the Food Board in 1921, he got hold of a little piece of cellular expanded rubber vulcanised under a gaseous pressure of 100 atmospheres, so as to produce an extremely large number of very minute pores bounded by very thin walls, and, as far as could be determined by such experiment as was possible on the sample, this had a conductivity only half as large again as that of still air, as against about double the conductivity of still air for a number of fine porous powders and fibres (cork, slagwool, charcoal and wood fibre). Hereabouts lies the lowest conductivity of any materials at present known, and this ceases to be maintained or even approached when the material is damp. As a very rough figure for comparison with the present results it may be called 0·3 B.Th.U.

Dr. Griffiths's present figures show that with two exceptions the materials of building construction have conductivities of quite different orders of magnitude. The lowest of those he examined are diatomaceous bricks, which have a conductivity of rather over twice to three times that of the porous powders, and a flooring material prepared on Dr. Schryver's process from exhausted castor beans also had a conductivity of about three times that figure. The next lowest is a chalk-cement (20 : 1) concrete, used for the walling of one of the experimental cottages erected by the Board at Amesbury, with a conductivity of 2·2, about seven times that of the powders. Ground brick and lime followed with a conductivity of 2·9, sand-lime (2 : 1) 3·3, sand-cement (4 : 1) 3·7, and so on among concretes and plasters up to York stone-sand-cement (4 : 2 : 1) 7; showing over all a conductivity in concretes and plasters varying from about 7 times that of the powders to something over 20 times. The usual walling materials have conductivities beginning in the higher range of the concretes. Thus Fletton bricks in cement-mortar are 4·4 and in lime-mortar 5, London stocks 6·1, pisé of clinkers and lime 8·1, and of clay and gravel 8·7, and sand-lime bricks in cement-mortar 9·3; say from about 14 to 30 times the conductivity of the powders. Both better and worse results were obtained from the cavity and composite walls. These results were, of course, not per inch, but for the total thickness, and cannot therefore be compared summarily with the figures just given. The best was 9·6 for a 6-in. timber frame construction, made of 1-in. rough boarding with 4-in. by 2-in. studding and lath and plaster, and ¾-in. weatherboarding, roughly about a third of the conductivity of the same thickness of London stock bricks in cement mortar; next came a wall of 12-in. by 9-in. by 6-in. hollow terra-cotta bricks, with a conductivity of 19·7. In most cases the sample wall or slab was made several weeks before test and allowed to dry out thoroughly. The extent, however, to which moisture would have affected the results was illustrated by testing a wall of 9-in. stocks fixed quite wet during June; what year or what temperature and conditions of atmospheric moisture are not stated. The initial conductivity was 15·8, which dropped in a week to 9·67 and took a further week to reach its normal 6·1. This indicates that in exposed conditions many porous materials would be worse than useless as insulators, though they might be serviceable as internal linings.

In his introduction to the report Mr. Weller draws attention to some practical consequences from its results. To indicate the effect of insulation on the domestic economy he compares the conductivities of sand-lime in cement and Flettons in lime, and calculates that the difference in conductivity shown from the above figures—about 10·7—amounts in a heating season of 170 days to a loss of heat that would take something over a ton of coal to make good, in the absence of which the house would be correspondingly "colder." This is apparently on the assumption of central heating with a 60 per cent. efficiency, and perhaps understates the effect in British conditions. Other results show that the insulation can be improved by building the walls with cavities. The framed timber wall, which gave the best results, is open to the objection that its insulating power is reduced greatly by leakage when the outer skin is split or broken, apart from other obvious disadvantages. Something approaching its insulating efficiency can, however, be got by building hollow brick walls. Thus a hollow 11-in. wall of London stocks would have a conductivity of little over 11, as against the 9·6 for the 6-in. framed timber wall. The whole of the figures are however affected by the process of manufacture; cement-concrete, for instance, becomes more conductive as it becomes denser and richer, and according to the Norwegian results light-burned bricks are less conductive than hard burned. It is stated accordingly that in these experiments care was taken to see that the experimental samples represented fair average practice in good work. The figures for pisé (rammed earth) indicate that it is more conductive than bricks for equal thickness, and owes its reputation for insulating power to the greater thickness in which it is used. Perhaps the most striking figure for practical purposes is that of the chalk-cement concrete, quoted above, of which the insulating power is roughly three times as great as that of London stocks in cement.

Two methods of test were used according to the order of magnitude of the conductivity in question, each of these depending on measuring the heat flowing normally to the surface through the thickness of the sample. In each method the source of heat was an electrical hot plate, consisting of a coil or mat of nichrome tape so wound as to communicate heat uniformly all over the surface, and insulated with thin sheets of micanite. For materials of high conductivity, such as walling, in which the heat flowing through the surface was large relatively to that which escaped from the edges and corners and had to be allowed for by a calculated correction, the sample of about 9 sq. ft. area was backed by the hot plate, and this again by a 6 in. slab of cork extending over and beyond the hot plate, the edges of the sample and hot plate being embedded in granulated cork held in a framework. By a number of copper-constantan thermocouples the temperatures of the hot and cold faces of the slab and of the wall under

* "Heat Transmission through Walls, Concretes and Plasters": H.M. Stationery Office. Price 1s. 6d. net.

test were taken, and from the electrical energy used in the hot plate and the temperature readings the total heat, loss through edges and corners, and conductivity of wall were calculated. With hollow samples duplicate tests were made in horizontal and vertical positions, disclosing differences of conductivity due to convection currents ranging from about 2½ per cent. to 10 per cent. Materials of higher conductivity were tested in duplicate slabs, each about 2 in. thick and 12 in. by 12 in. area. These slabs were provided with metal faces and sandwiched about the hot plate, which in this arrangement was surrounded by a "guard-ring" of the same construction and in the same plane as itself, and from a separate supply of current maintained at the same temperature, so that no flow of heat took place from the edges and corners of the hot plate.

A brine circulation in pipes was provided against the outer metal plates fixed to the samples, so as to treat them as cold faces and maintain them at a constant low temperature, and the whole was embedded in granulated cork. From the electrical energy and the temperatures of the hot and cold faces of the slabs, taken with thermocouples at various points, the conductivity was calculated. The readings reckoned in the test were not begun till a steady flow of heat had been established, which might take some days.

It is regrettable that this report, including as it does much accurate and valuable work, cannot be described fairly without the remark that the exposition of the material is in many ways unsatisfactory. In what reads like a stock description of thermal conductivity it is stated, for instance, that observations were made of "the gradient of temperature through the material." Such observations are not reported, nor, indeed, do they seem to have been required; what was observed were the temperatures of the hot and cold faces, and the temperature gradient is not mentioned except that the test was not begun till the temperature differences were constant.

A slab of baked cork, 5 ft. 6 in. square by 6 in. thick, is said, again, to have been made up from pieces 36 in. by 9 in. by 3 in. thick. This would seem to be impossible without cutting, in which case the reason for giving the dimensions of the pieces is not evident. Data obtained with two such slabs are given in a table which seems to be reprinted from a Food Board Report, except that for some reason the year of experiment (1919), which was stated in the old table, is omitted from the present one. The mean temperature of the insulating material is given in this table without any indication either here or elsewhere of how it was obtained. This is the more regrettable because in some instances it is different by several degrees from the average of the corresponding hot and cold face temperatures. Probable values, again, are given for the calculated conductivities, but no statement is made of how these values are calculated, and on the face of them they cannot be derived from the constituent figures to which they refer without further information than that given. In the determination of the conductivities of walls, again, a formula is given for calculating the correction for heat escaping otherwise than normally through the surface; but though the report condescends to the definition of a British thermal unit, the method of calibrating a thermocouple, and other elementary details—and is none the worse for doing so—no explanation is given of the way in which this formula is obtained, except a reference in a footnote to an American journal which is not to be found in all good technical libraries.

Defects such as these and a certain incoherence of description doubtless leave the results embodied in the principal tables unaffected. They have, however, appeared to a greater or less extent in other recent reports from the Research Department and its Boards, and in particular more than one of these has shown an inconsequence of treatment, such as might be expected if the report had been a compilation of contributions by a number of writers. This adds greatly to the difficulty of making sense of the contents, and sometimes even leaves discrepancies between statements in various parts of the same report. It is to be hoped that in future reports it may be recognised that the valuable experimental work initiated by the Department and its Boards deserves better treatment.

PATENT STATUTES.

THE patent law of this country is a Statute Law as distinct from Common Law, that is to say, it is governed by Acts of Parliament and not by common usage, so that its provisions are substantially well-defined. In a sense, however, it arises from the Common Law, for it was the practice of the sovereign to grant Letters Patent covering monopolies of many kinds, not only those limited to inventions. This became so oppressive to trade that in 1623 the people in this country, essentially a trading community, obtained the passing by Parliament of the famous Statute of Monopolies. This may be summed up for the present purpose in two phrases:—

(*a*) It declared all monopolies illegal.

(*b*) It excepted from this declaration Letters Patent for inventions which were to have the same effect as though the Statute had not been passed.

This being the fundamental basis of Patent Law it is necessary to examine carefully the first and sixth sections which are directly applicable. The transcript of these sections given in Frost's Law and Practice relating to Letters Patent for Inventions is as follows:—"The first section declares and enacts that all monopolies . . . and Letters Patent heretofore made or granted or hereafter to be made or granted to any person . . . whatsoever of or for the sole buying, selling, making, working or using of anything within this realm . . . or any other monopolies . . . are altogether contrary to the laws of this realm and so are and shall be utterly void and of none effect and in no wise to be put in use or execution."

The sixth section provides that "any declaration before-mentioned shall not extend to any Letters Patent and grants of privilege for the term of 14 years or under, hereafter to be made, of the sole working, or making of any manner of new manufactures within this realm, to the true and first inventor or inventors of such manufactures, which others at the time of making such Letters Patent and grants shall not use, so as also they be not contrary to the law or mischievous to the State by raising prices of commodities at home or hurt of trade or generally inconvenient; the said 14 years to be counted from the date of the first Letters Patent or grants of such privilege hereafter to be made, but that the same shall be of such force as they should be if this Act had never been made and of none other." Several Statutes followed this, but the first modern Statute was that of 1883, from which date present day patent law and practice might be said to run. This consolidated Act of 1883 placed the whole matter of patents on a sound basis and settled reasonable Patent Office procedure.

The next Act of importance was that of 1902, which came into force three years later, namely in 1905, and for the first time provided that the Patent Office should make a search to ascertain to some degree the novelty of an invention before Letters Patent were granted. It was for this reason—because of the increased staff necessary, the making of indexes and the like—that such a large lapse of time occurred after the passing of the Act before its coming into operation. The search to be made was through British specifications only, and was limited to a period of fifty years. It did not, therefore, ascertain the true novelty of the invention nor, indeed, does the present day search do so, but it did give the Patent Office power which they did not possess before to advise the public if they were granting a patent for the same invention twice. It did not permit the Comptroller to refuse the grant even although he had already accepted a specification covering the same field, but it gave him the right to introduce what was called the "statutory reference" into the specification. More accurately, and this should be noted for it still applies, the reference was not to be in the specification itself but at the end of the document, and as a mere notice to the public having no bearing on the true construction of the document. It cannot be taken into consideration in court proceedings in interpreting what the inventor meant or what is the true interpretation of the specification or its claims.

This Act also, to a certain extent, defined novelty in that it provided that an invention covered by any patent applied for on or after January 1, 1905, shall not be deemed to have been anticipated by reason only of its publication in a specification left, pursuant to an application made in the United Kingdom not less than fifty years before the date of the application for the patent, or of its publication in a provisional specification on any date not followed by complete specification.

Following this Act, namely, in 1907, the next consolidated Act was passed, the 1902 being a short Amendment Act to the Act of 1883. This Act contained many features of importance, and for the first time enabled the Comptroller to refuse to grant a patent if he had already accepted an application which pre-published it, and wholly and specifically claimed what was claimed in the later document.

The main part of this Act is still in force. It was followed by a series of temporary provisions which dealt with matters arising during the war, but with the exception of certain special Acts in connection with the peace treaties these have now ceased to be in force. After the war the Patent Act of 1919 was passed. This is an amending Act, varying the provisions of the Act of 1907 and the present Patent Law comprises the Act of 1907 as amended by the Act of 1919.

In the first place the Act of 1919 is important because it extends the term of the grant of Letters Patent from fourteen years to sixteen years. The Act, as printed, does not in fact refer to any amendment of the Statute of Monopolies which limited the term to fourteen years, though presumably it automatically makes this amendment. The consolidated act has been printed in two or three recognised legal works, and recently an official issue has been made by the Government Stationery Office. There are 22 sections in the Act of 1919, practically 100 sections coming into consideration when it is consolidated with that of 1907. It is clearly impracticable to deal with these in detail at the moment.

THE BRITISH ASSOCIATION.

OLD members, who had attended the fourth Liverpool meeting of 1896, were glad to find themselves back in the splendid Reception Room in the grand St. George's Hall, and to transact their technical business once more in the buildings of the University. Nearly all the sections are accommodated in the University, to reach which the Corporation has arranged for a special free service of motor omnibuses. This is in addition to the old privileges of British Association members of the free use of the tramways and omnibuses. The local handbook, which Dr. Alfred Holt, M.A., one of the honorary local secretaries, has edited, is another reminiscence of the last Liverpool meeting. It is not merely a guide to Liverpool, but it deals with the whole district in its various aspects, and is issued under the title "Merseyside." We need hardly say that Mr. J. A. Brodie, the city engineer, Mr. L. A. P. Warner, the general manager to the Mersey Docks and Harbour Board, Dr. J. G. Adami, the Vice-Chancellor of the University, and the archæologists and other scientists, as well as commercial men, have done their best to make this pocket book instructive.

It will be a strenuous week for those who have come to learn. In addition to the well-stocked Exhibition of Scientific Apparatus, which has been arranged by Mr. F. W. Bain, and which was opened by Sir Charles Sherrington, last year's president, on Monday, scientific novelties in great variety will be shown in connection with Tuesday's Soirée, for which the University has issued invitations, while visits to works and excursions will make it hard for members to take their choice. The Meteorological Department of the Air Ministry will, as before, keep the members informed as to probable weather changes.

THE PRESIDENTIAL ADDRESS: THE ELECTRICAL STRUCTURE OF MATTER.

The inaugural meeting, held in the Philharmonic Hall on Wednesday, at 6.30 p.m., brought an

innovation which was much appreciated by both old and new members. Sir Charles Sherrington introduced the President-Elect, Sir Ernest Rutherford, F.R.S., of the Cavendish Laboratory, Cambridge, and the Lord Mayor, Mr. Frank C. Wilson, welcomed the Association in accordance with old-established custom. But Sir Ernest did not read his address, which is of considerable length. Many a president in previous years had rather wearied his audience with details which only the initiated could grasp, and the complimentary speeches had been long. Sir Ernest spoke, on what he called the "Heroic age of Physical Science," explaining pithy points of his "Electrical Structure of Matter" by experiments, some of them novel. The vote of thanks was proposed by Sir Oliver Lodge and seconded by the Honorary Treasurer of the Association, Dr. E. H. Griffiths, in short speeches. The Treasurer also announced the attendance figures. In 1896 the total number of members had been 3,181; this year the total is, so far, 3,000. The expectation of a good meeting has thus been realised, though the fourth meeting has not been eclipsed. The year 1896 was one of great scientific excitement, as we recalled in the introductory article on page 272 of our issue of August 31. Much of that excitement has meanwhile passed into a state of steady development, and though Sir Ernest Rutherford in particular continues to give the old science of those days many a shock, we begin to see how simplicity may grow out of apparent confusion. We deal with the presidential address in our leading article on page 337.

All the sections opened their transactions yesterday, Thursday morning, at 10 a.m. Mathematicians and physicists, chemists and engineers, *i.e.*, members of Section A, B and G, began their work by a joint discussion on "Cohesion and Molecular Forces," with which we shall deal next week.

THE INSTITUTE OF METALS.

THE autumn meeting of the Institute of Metals was held this week in Manchester under the chairmanship of Mr. Leonard Sumner. The proceedings were opened on Monday, September 10, in Milton Hall, Deansgate, when Lieutenant-Colonel Sir Henry Fowler delivered the second Annual Autumn Lecture, taking for his subject "The Use of Non-Ferrous Metals in Engineering."

In his opening remarks the lecturer said that there were probably more papers presented at the meetings of that Institute than at those of any other. That indicated the great amount of research work which was being conducted on the non-ferrous metals, but it was noticeable that the contents of the papers were mainly of a very theoretical description. In consequence the value of the work in practical life was not appreciated to the extent that it should be. The object of the lecture, Sir Henry said, was not only to show how the non-ferrous metals were put to use, but also to indicate the extension of their application as the result of research work.

Copper was the earliest used metal of the type, and knowledge of some of its early uses has been forgotten. For instance, the treatment to give it a cutting edge had been lost because the need for that knowledge has also passed away. In this country and in Europe generally copper was the metal chiefly used for locomotive fire-boxes and stays, and to a certain extent for locomotive tubes. The troubles which caused the necessity for removal of the plates of a locomotive fire-box were the wear at the sides, and the cracking where bending had taken place and in certain cases round the stud holes. Wear was probably due to the combined actions of corrosion and oxidation but had been diminished by adding from 0·35 per cent. to 0·5 per cent. of arsenic. Cracks were the result of repetition stresses, but to what extent they were due to the presence of oxygen cannot be stated. It was, however, a fact that if the oxygen exceeded 0·15 per cent. in a copper containing 0·35 per cent. to 0·50 per cent. of arsenic, it was liable to give trouble in the bending essential to manufacture. This and other similar questions were being investigated by Dr. Walter Rosenhain on behalf of the Non-Ferrous Metals Research Association. In locomotive boiler work the troubles were more often than not due to the copper stays, which connect the inner copper to the outer steel plate of the firebox. The trouble was mainly the gradual disappearance of the riveted head on the fire side. It was essential that if copper was to be tough a certain amount of oxygen must be present in the metal when finished. As heating such copper in a reducing atmosphere made it short, every care must be taken in engineering work not to allow the temperature to rise above 800 deg. to 850 deg. C.

The two great alloys of copper were bronze and brass, and these possessed the advantage of ease of casting. Few of the copper-tin alloys had a higher tensile strength than copper, while their elongation fell away as the percentage of tin was increased. Gun-metal was the most used of all the bronzes. It commonly contained about 10 per cent. of tin with small percentages of zinc and lead. Zinc acted as a deoxidiser and its presence gave castings much freer from defects, while lead made it much more easily worked in the lathe. Neither metal was desirable if present in a larger quantity than 2 per cent. Heat treatment, such as raising to temperatures above 500 deg. C. and then quenching, increased the tenacity and elongation of the metal, but gave a soft homogeneous material which was unable to resist wear. Instances of tests on this were cited by the author.

Brass castings were easily produced, and if they contained a certain percentage of lead were easily machined. Pipes and stampings were made possible of production, as the result of the investigations of Muntz, with a mixture of 60 per cent. copper and 40 per cent. zinc.

The subject of bearing metals was of great importance. Those known as white metals consisted usually of tin-antimony-copper-lead alloys and contained hard tin-antimony crystals in a softer matrix of tin or lead. When the loads were great a harder matrix was required, such as was obtained when a higher percentage of tin and some copper was introduced. The compositions of the bearing metals adopted by the railway authorities were quoted to show the change of properties with composition and to show the suitability of each for a certain class of work.

Aluminium, by itself was not a suitable material for engineers' use, but its alloys were of great importance and the knowledge of their properties was gradually extending. The author briefly surveyed the field of the aluminium alloys giving credit to the individual research workers and showing the scope of the materials they had introduced. He hoped for the strengthening of the various metallurgical research organisations by association with engineers.

In his remarks prior to proposing a vote of thanks to the lecturer, the chairman said that the metal manufacturers suffered very much from a lack of knowledge of the use of the materials they produced. Such ignorance was the cause of a great amount of disappointing work which could be removed if the co-operation of engineers was obtained.

At the meeting on Tuesday morning, September 11, Mr. Leonard Sumner, the president, was accompanied on the platform by the Right Hon. the Lord Mayor of Manchester, Alderman W. Cundiff, who extended a welcome to the members in a brief address.

RED STAINS ON SHEET BRASS.

The first paper submitted was one by Mr. E. A. Bolton, on the subject of "Red Stains on Sheet Brass." Although harmless from a mechanical point of view the markings have the effect of lowering the value of the sheets on the market. The author described a series of experiments to determine the causes of their presence. These were found to be very numerous, but the chief was the impinging of hot flames and gases on the metal during the annealing. The paper concluded with brief references to possible remedies of the trouble.

Professor Thomas Turner referred to a case when the cause was due to the use of water from a canal adjoining which there was a galvanising works. Speaking broadly the stains were due to the deposition of copper when the sheets were in the pickling solution. The author thanked the professor for his contribution and for the advice and criticism he had received from him.

BRINELL HARDNESS NUMBERS.

Mr. H. W. Brownsdon then presented a paper on the subject of "Brinell Hardness Numbers," in which he drew attention to the necessity for the expression of results in figures that may be comparable. This was obtained when the value found by dividing the load in kilogrammes by the square of the ball diameter in millimetres is kept constant. A diagram was shown to indicate the variations of the quotient obtained for hard and soft copper and brass. The difficulty would, the author thought, be overcome by agreeing upon some value for each class of alloys, and suggested that for the copper group with Brinell numbers of from about 40 to 200, the choice should rest between 5, as standardised in the United States of America, or 10, which was favoured by some workers in this country.

Dr. R. H. Greaves and Dr. Walter Rosenhain spoke, and they approved the adoption not of some fixed value for the ratio load to the square of the diameter of the ball, but of a series to suit the different groups of metals.

STEREOTYPING.

In a paper on this subject, Messrs. A. H. Mundey and John Cartland described the process as invented by Ged in 1750, and traced its evolution. The modern system of preparing an impression of the type and blocks on the *papier-maché* flong and then using it in the casting machine as the mould for the stereoplate was shown as a preliminary to discussing some of the metallurgical problems involved in the process. The alloys used varied according to the character of the work, the tin content was from 5 per cent. to 10 per cent., antimony from 15 per cent. to 19 per cent., and the remainder lead. One peculiarity which was emphasised was that new alloys do not work so satisfactorily as those that have been melted repeatedly.

Dr. Rosenhain spoke of his experiences with stereotype metal and said he would like to see a eutectic used for the purpose, but Mr. Mundey, who replied, said that with what was at present available the printer could not get anything like so good results as with the ordinary alloys.

CRYSTALLISATION EFFECTS.

A paper describing a research into the question of "Crystallisation Effects on Galvanised Iron" was presented by J. D. Hannah and E. L. Rhead. The conclusion the authors have come to was that the effect was mainly due to the presence of lead in the galvanising metal.

COOLING EFFECTS ON METALS.

"Effects of Rates of Cooling on the Density and Composition of Metals and Alloys," was the title of a paper by Dr. R. C. Reader. Two rates of cooling only were considered, fast and slow, as produced by casting in chill and sand moulds. The results showed that the densities of pure metals were not affected by the rate at which they solidify, and the same applied to those alloys which solidify at a constant temperature. With others, which have a range of temperatures for solidification, the properties were found to vary with the rate at which they passed through the range.

In the absence of the author the paper was taken as read and contributions to a written discussion were invited.

NICKEL IN BEARING METAL.

A note on "The Effects of Small Quantities of Nickel upon High-Grade Bearing Metal," by A. H. Mundey and C. C. Bissett, was read at the meeting, but no discussion took place. This note is reprinted in abstract on page 347 of the present issue.

CHANGE OF VOLUME IN METALS.

The last paper submitted to the meeting on Tuesday morning was one by Mr. Hikozô Endo on "The Measurement of the Change of Volume in Metals during Solidification." The measurements of the change in volume for a number of metals having low melting-points up to 1,100 deg. C. have been effected, and these were given in the paper. The method of measurement consisted in the

determination of the change of buoyancy of a metal suspended in an inactive liquid during its solidification or melting by means of a thermo-balance.

NEW METALLURGICAL LABORATORIES.

On Tuesday afternoon visits were made to many of the largest works in the district, and in the evening the new metallurgical laboratories of the Manchester University were opened by Sir George T. Beilby. The guests were received in the Whitworth Hall by Sir Henry Miers, Vice-Chancellor of the University. In the course of his address Sir George Beilby showed how experiment and observation were the foundations on which all progress was built up.

An announcement was made by Mr. J. Phillips Bedson, of Messrs. Richard Johnson and Nephew, Limited, that one of the original members of the Institute of Metals, Mr. Ernest Johnson, had presented funds to found a medal in the Department of Metallurgy, in memory of Henry Cort, the eminent metallurgist; this medal was to be awarded to the best student of each year.

At the Wednesday morning meeting in the College of Technology, Mr. Leonard Sumner presided, and a number of papers were read and discussed.

CONSTITUTION AND AIR-HARDENING OF ALLOYS.

The first paper was a communication which forms part of the report of a research carried out for the Engineering Research Co-ordinating Board, Aeronautics Research Committee, and was presented by Miss Marie L. V. Gayler, of the National Physical Laboratory. It dealt with the quaternary alloys of aluminium, copper, magnesium and magnesium silicide, containing up to 6 per cent. of copper, 4 per cent. magnesium and 4 per cent. magnesium silicide. The results showed that when the substances mentioned are present in aluminium any two of them have a marked effect on the solubility of the third. If copper and magnesium were present in a ratio greater than 12 to 5 approximately, the alloys when quenched from high temperatures age-hardened at room temperatures. With a less ratio no age-hardening took place. The slight increase in hardness which was obtained on further heat treating the quenched and aged alloys, was attributed to the small difference in solubility of copper at the quenching and ageing temperatures. It was shown that the age-hardening of alloys of the "Duralumin" type was due to the magnesium silicide.

Dr. W. Rosenhain opened the discussion by stating that the work was not merely academic, but of immense practical importance as it marked the beginning of the study of the quaternary system. It was impossible to understand what the materials used in practical work were capable of until such experimental results as were given in the paper were appreciated and extended to cover other combinations. Work on the aluminium alloys had put them in the position that the constitution and properties of that group were understood to a greater extent than any other. The Y alloy, which was of great value, normally had a tensile strength of 25 tons to 26 tons, but they had now succeeded by methods, such as those referred to in the paper, in raising that value to 31 tons and the limit had not been reached yet. Though papers of the character of that of Miss Gayler were regarded as difficult to understand their value in the future would be very great.

Dr. J. L. Haughton congratulated the author on presenting the first paper upon the subject of alloys of the quaternary system. He noted that for the purpose of this work she had chosen a series consisting of three pure metals and a compound. No doubt the reason for that was the important part played by magnesium silicide in the hardening actions. Perhaps the treatment might have been simplified by taking silicon as the fourth component.

In reply, Miss Gayler said she was glad Dr. Rosenhain had gone to such pains to make clear the practical significance of the work. In regard to the question of considering a compound as one of the four constituents of the series, she stated that magnesium silicide was so important that it would not clarify the treatment to consider it in any other way than as a compound.

THE ELECTROCHEMICAL CHARACTER OF CORROSION.

The next paper was on "The Electrochemical Character of Corrosion," and was submitted by Mr. Ulick R. Evans. In it the results were given of many experiments which showed that the corrosion of metals was mainly, probably entirely, an electrochemical effect. The actions may be considered as of two types. The first was characterised by the evolution of hydrogen gas and was found when reactive metals were placed in acid solutions. The rate at which that took place depended on the degree of purity of the metal. The second type of action was much slower and took place at a rate which was fixed by the diffusion of oxygen to the metal and was comparatively independent of the purity of the metal. When a piece of metal was placed in a solution of potassium chloride the production of alkali at the cathode, of the chloride at the anode, and the precipitation of the hydroxide were all observed. The current that passed could be measured and was found by the application of Faraday's law to account for the greater part of the corrosion actually observed. It was generally the case that the cathode was the area to which air had free access while the anode areas were those protected from aeration. It was also a significant state of affairs that corrosion commonly took place most rapidly at the comparatively unaerated places, and that was particularly noticeable in "pits" and over the areas covered up by the porous corrosion products.

Dr. G. D. Bengough said he thoroughly disagreed with the paper. He and the author held two conflicting sets of views, out of which the truth might emerge. The author had based his views on four points; that pure metals were incorrodible, that ordinary metals contained impurities that formed cathodes, the effects of the oxygen concentration cells, and that all the actions were electrochemical. He, the speaker, disagreed entirely with the views of the author on the first three of those points, but on the fourth he agreed that electrochemical actions might cause corrosion, but did not account for all that was observed. When the anodes and cathodes had become so close to one another as to be indistinguishable by any known process the chemical and electrochemical actions must merge and become the same thing. Dr. Bengough thought that many of the actions credited to oxygen concentration cells were caused by metal concentration cells. He took exception to some quotations in the paper of experimental investigations in which iron and lead had been got in so pure a state that no corrosion took place. The reports, he thought, showed quite a different state of affairs. As it was possible to have both cathodes and anodes in a piece of pure metal it was possible to have corrosion. Of the definitely new experimental work in the paper he could not agree that the author's interpretation of the results was the correct one. He contended that where most oxygen was found the corrosion was greatest, and discussed the manner in which oxygen got at the metal at the foot of a "pit."

Other speakers disagreed with the entire acceptance of the theory of electrochemical action.

Mr. Evans Murphy stated that the production of current had been demonstrated, the amount of current produced had been compared with the resulting corrosion, and that the amount of the action was accountable for in that way. If the actions were not electrochemical how was it that they occurred to the greatest extent in "pits"? The current produced, unless allowance was made for polarisation, was actually more than what was required to account for the corrosion.

TEMPERATURE AND COLD-WORKING EFFECTS UPON THE COHESION OF COPPER.

A paper on "Some Experiments on Copper Wire, Cohesion a Function of both Temperature and Cold Work," was presented by Mr. Douglas H. Ingall. In the tests referred to five samples of copper wire were used. They were all in different states, the first was soft annealed copper and the other four in stages of cold-working as represented by 25 per cent., 40 per cent., 50 per cent. and 75 per cent. reduction in area by wire-drawing. The change from one grade to another was obtained in a single pass through the dies. The cohesion at high temperatures was found by placing particular loads on the material at room temperatures and then heating the wire and finding at what temperature it broke. When the graphs connecting cohesion with temperature were drawn they all showed similar characteristics. The cohesion dropped as the temperature was increased, according to a straight line law until a constant critical temperature of 350 deg. C. was reached, after which the cohesion was represented by a sharply descending curve. The fractions obtained when the copper was above the critical inflection temperature of 350 deg. C. were brittle in character and intergranular, while at lower values they had a normal appearance. At the critical inflection temperature the material was comparatively fragile.

Dr. F. Johnson offered the congratulations of the members on the contribution of a valuable piece of work, while Mr. T. G. Bamford said that as the result of the author's work manufacturers would be able to know what the strength of their products would be at different temperatures, and Mr. W. Ernest Alkins spoke of actions like fire cracking with copper, which the workers called crazing.

The author, Mr. Douglas H. Ingall, thanked the speakers and the members for their reception of his work.

THE EFFECT OF OXYGEN ON COPPER.

Miss Grace W. Ford then presented a paper on "Investigations of the Effects of Impurities on Copper. Part I.—The Effect of Oxygen on Copper," on behalf of Dr. D. Hanson and Mr. C. B. Marryat, with whom she was associated in its preparation. We begin the publication of this paper in an abridged form on page 351 of this issue.

Sir Gerard A. Muntz, Bart., opened the discussion by stating that the paper was the first of what promised to be a very big piece of work. He regretted that it was thought necessary to go right away back to the beginning, as the experiments concerned matters about which information could have been got right away from the people on the works. It was not fair to say that no work had been done in investigations with pure copper. What might have been said was that nothing had been published. It was known that if there was too much oxygen in copper it could not be worked without cracking.

Dr. W. Rosenhain spoke of the association of himself and Sir Gerard in connection with the research, and said that, though many things found in the results were said to be well known, they had found in research work that it was necessary to test out some of that type of knowledge. As the knowledge referred to was only gathered in the cases of special materials and special methods of working it was vitally necessary to go right back to the beginning and test out everything. The work had shown that it was possible to get sound copper billets although that was not attainable before. He wished to express his thanks to the Non-Ferrous Metals Research Association for permission to allow the presentation of the paper to the Institute.

Dr. F. Johnson regretted that the authors had made no reference to previous investigations such as those conducted in America. Co-operation in the prosecution of the work between the research staff and producers might make large scale operations possible. The presence of oxygen in copper was not wholly bad as it had some advantages. The authors stated that 0·1 per cent. of oxygen had no effect, but he could not agree with them.

Dr. Hanson replied for the authors and stated that if they were to investigate the effects of oxygen on copper they must start with pure copper. Their aim was quite different from that of the manufacturers, who used de-oxidisers, as they desired a completely pure metal to begin with.

HARDNESS TESTS ON CRYSTALS OF ALUMINIUM.

A paper with the above title contributed by Mr. Hugh O'Neill was taken as read. Brinell tests showed that at low loads the different crystallographic planes resisted penetration to different degrees and gave indentations of different shapes. Crystal boundaries were found to have no appreciable effect in increasing the resistance of aluminium to penetration.

METALS UNDER COMPRESSIVE STRESSES.

Mr. H. I. Coe next presented a paper on "The

Behaviour of Metals under Compressive Stresses," which is reprinted in abstract in this issue, on page 349.

Mr. T. H. Turner called attention to the value of the double cone theory in regard to compressive actions, and Mr. Coe said in reply that it was possible to pick up the two cones in the harder materials, but with most of those used he was inclined to doubt their existence as the metal was too soft.

Two other papers, the one on "A Dilatometric Study of the Transformations and Thermal Treatment of Light Alloys of Aluminium," by Messrs. Albert M. Portevin and Pierre Chevenard, and the other on "Equilibrium in the system Gold-Zinc," by Professor P. Soldau, were taken as read.

The meeting was closed, on the motion of the President, with votes of thanks to all who had contributed to make the visit to Manchester a success.

THE UNITED STATES AIRCRAFT CARRIER "LANGLEY."

In view of the important part which aircraft are destined to play in naval warfare of the future, considerable interest is being displayed in the provision now being made for them by the great naval Powers. For the British Navy the aircraft carrier Hermes, a vessel of 10,950 tons displacement has recently been completed, while the Eagle, of 27,790 tons displacement, is still under construction. Older vessels of the same class are the Furious, now being reconstructed, the Argus, the Pegasus and the Ark Royal. All these vessels, with the exception of the Hermes, were originally designed for other purposes, and afterwards converted for use as aircraft carriers, so that, up to the present, the Hermes is the only vessel in which our naval constructors have had a perfectly free hand in the matter of design. This ship was laid down in January, 1918, and was launched in September of the following year by Messrs. Armstrong, Whitworth and Co., Limited. She was completed at Devonport and has recently carried out her trials. Parsons turbines designed to develop 40,000 s.h.p., are installed and these give the vessel a speed of 26 knots. The extreme length of the ship is 598 ft. and the width of the flying deck is 90 ft., the beam being 70 ft. 2 in. and the draught 18 ft. 9 in.

The total displacement tonnage of the six British aircraft carriers is 77,440, which is rather more than half the total tonnage of this class of vessel, *i.e.*, 135,000 allowed us under the terms of the Washington Treaty. The United States are allowed the same total tonnage of aircraft carriers as Great Britain, while the corresponding figure for Japan is 81,000 tons and for France and Italy 60,000 tons each. In general, replacement of this class of tonnage can take place after twenty years, but vessels built or building at the end of 1921 may be treated as experimental and may be replaced if desired without regard to age. The whole of the British aircraft carriers, it may be remarked, would be included in this latter category. It is also laid down by the terms of the Treaty, that the tonnage of each unit shall not exceed 27,000 and that armament of greater calibre than 8 in. shall not be mounted on aircraft carriers.

The above general particulars of the present position with regard to aircraft carriers may be of interest in connection with the account of the first aircraft-carrying ship to be completed for the United States Navy which we now propose to give, making use for the purpose of information contained in a paper by Lieutenant-Commander H. R. Keller, U.S.N., reprinted in the Journal of the American Society of Naval Engineers. This vessel, which was commissioned on March 20 of last year, has been named the Langley, in memory of the late Professor S. P. Langley, whose work in connection with the development of aviation is well known throughout the world. Actually the vessel is the former fleet collier Jupiter, rebuilt for her present duties. The Jupiter, it will be remembered, was the first vessel in the United States Navy to have electric propelling machinery installed on board, and her trials in 1914 aroused considerable interest at the time. Some particulars of the results obtained will be found on pages 506 and 619 of our 98th volume, while details of the machinery were given on pages 273 and 387 of volume 94. The machinery installation, we may mention, consists of one six-stage Curtis turbine, rated at 5,000 kw., driving a three-phase alternator which supplies current to two motors, one placed on each propeller shaft. The normal speed is about 14 knots, and at this speed the turbine runs at 2,000 r.p.m., and the propeller shafts at 110 r.p.m. No alterations have been made to the main propelling machinery during the work of reconstruction, so that the description of the installation above referred to still applies.

The boiler installation is also the same as that of the Jupiter, except that the boilers have been converted for burning oil fuel. There are three double-ended Scotch boilers, each 23 ft. 0¾ in. in diameter and 16 ft. 3 in. long, while the working pressure is 190 lb. per square inch. The boilers work under forced draught on the Howden closed ash-pit system, the air being supplied by four Terry turbine blowers, each capable of delivering 15,000 cub. ft. of air per minute. Fuel oil is carried in the double-bottom tanks and in two deep tanks forward of the break in the forecastle, and these tanks have a combined capacity of 550,000 gallons. Three-inch suction and filling lines lead from the tanks to the manifolds in the stokehold. A service tank of 8,000 gallons capacity is located in the pump room forward of and in communication with the stokehold. Two duplicate systems are provided for the fuel-oil service; each system consisting of two pumps and one heater with the necessary connections to the fuel-oil manifold. One set of pumps is located in the pump room forward and the other is mounted on the after bulkhead of the stokehold.

The method of disposing of the flue gases is interesting and the arrangements are as follow: The uptakes from both ends of the first boiler and from the forward end of the second boiler are connected to the starboard side of a large athwartship trunk, while the uptakes from the after end of the second boiler and from both ends of the third boiler are connected to the port side of this trunk. On the port side of the vessel, the athwartship trunk is connected to a funnel which extends upwards from a blister foundation on the ship's side at the poop deck level to a height of about 8 ft. above the flying deck. This funnel can be raised or lowered by means of an electric motor so that it can lie horizontally with the outlet directed either forward or aft. On the starboard side of the ship, the athwartship trunk is inclined downwards and terminates in an elliptical opening measuring 7 ft. by 11 ft. This opening comes between the poop deck and the after superstructure deck at the side of the ship. (See Fig. 1 on the next page.) Dampers control the outlet of the gases from the funnel or from the opening on the starboard side, and the dampers are so arranged that when one outlet is in use the other is closed. In order to cool the gases, and by this means to reduce the effect of the heated gases in causing "bumps," the starboard outlet is fitted with a water-spraying device which consists of two jets supplied from the fire mains of the ship and fitted into the trunk about 6 ft. from the end. The downward inclination of the outlet end of the trunk, of course, ensures the whole of the water being discharged overboard.

The only other alteration to the machinery installation which need be referred to concerns the electric generators, to accommodate which a new dynamo room has been constructed in what was formerly a coal bunker on the starboard side of the second deck above the engine room. Originally, three 35-kw. turbo-generators were used for the field excitation of the main generators and for lighting and heating the ship. Two of these generators are now used for field excitation only and three 200-kw. turbo-generators have been installed to supply the additional requirements for electrical energy of the ship in her new capacity. Two of these generators are located in the new dynamo, where the switchboards are also situated.

The duties of an aircraft carrier are, of course, to provide a floating platform from which aircraft can take off and on which they can alight, and also to provide the necessary facilities for the repair, maintenance, operation and storage of the machines carried. The only characteristic of the vessel in her former capacity which rendered her at all suitable for conversion into an aircraft carrier was the large hold space which could be utilised for storing the machines. Her low speed is, of course, a drawback, but we gather that she is intended mainly as an experiment to assist in the design of the equipment for the two large aircraft carriers Lexington and Saratoga, recently authorised by Congress. These two vessels were originally designed as battle-cruisers, but were not proceeded with after the Washington Agreement. They will be fitted with turbo-electric machinery in the development of which the Jupiter played an important part, and it is interesting to notice that the same vessel will now contribute to their design from the aviation standpoint.

The Langley has a length of 520 ft. between perpendiculars and of 542 ft. 2½ in. overall, while her moulded breadth is 65 ft. and her moulded depth to the sides of the main deck is 39 ft. 9½ in. The appearance of the vessel is well shown in the half-tone engraving, Fig. 1, on page 343, and a general idea of the internal arrangements can be obtained from the longitudinal section reproduced in Fig. 2. The flying deck is supported on 26 towers, symmetrically located on each side of the vessel and at a height of 30 ft. above the main deck level. The towers are of rectangular section and are built up of angle bars suitably braced. Two hatches, fitted with balanced covers, give access to the after part of the deck, which is 65 ft. in width and 523 ft. long. The deck can also be reached through a signal hatch forward. The flooring is of wood planking with expansion joints at intervals as indicated in Fig. 2, and it is normally kept entirely free from all obstructions. There are, however, two telescopic masts which can be raised or lowered at will and which, when raised, extend to a height of about 50 ft. above the level of the deck. A system of palisades is also provided in order to reduce the wind velocity over a limited area of the flying deck, so that machines can be overhauled or secured on that deck if desired. The palisades are located on the deck in the form of a rectangle, the after end of which is left open, and they are formed of five groups of channel bars, 6 in. wide and 12 ft. long, which can be raised and lowered by electric motors. There are 40 of these channels in the forward end of the rectangle and 20 in each of the sides; the open space between the channels is about 10 in. wide. Life nets extend along the whole length of the deck on both sides, and these are supported on hinged stancheons so arranged that the net can stand vertically for a height of 3 ft. above the deck level or lie horizontally along the sides about 4 ft. below the deck. Mechanics can stand in the nets in the latter position while machines are landing on the deck. The arresting gear for bringing machines to rest on the deck is an important feature of the design, but details of this are not, at present, available for publication. Neither is it possible to give full particulars of the catapults, one of which is provided at each end of the ship for launching machines into the air. We may mention, however, that the machine rests on a carriage which is propelled by compressed air and is retarded by a pneumatic brake after the machine has been launched. The track on which the carriage travels is 180 ft. long for the forward catapult and 145 ft. long for the after catapult. Both were designed and constructed at the Naval Aircraft Factory, Philadelphia.

Another important feature of the vessel is the elevator provided in the position shown in Fig. 2 for the purpose of lowering the machines from the flying deck to the well deck, or, of course, of raising them from one deck to the other. The elevator platform is 36 ft. wide and 46 ft. long, these dimensions being sufficient to accommodate a complete machine of the type with which experiments are being conducted. The elevator works on vertical guide rods between the two decks, the weight of the platform being balanced by three sets of counterweights on each side. It is operated by wire ropes from two hoisting drums, situated in the space below the elevator and driven by a 17½ h.p. electric motor controlled from a station on the well deck. The elevator is capable of lifting a load of five short tons at a speed of 20 ft. per minute.

The four aircraft stowage holds are situated between the well deck and the inner double bottom, two forward of the elevator space and two aft of it, as shown in Fig. 2. The holds, which are capable of accommodating about 50 machines, from which the wings have been removed, are all 64 ft. wide and vary in length from 40 ft. to 42 ft. In the case of the forward hold, the available head-room is about 36 ft., but in the others the height is reduced to 32 ft. on account of the greater depth of the ballast tanks. Each hold is ventilated by two ducts on each side, the air being supplied by a blower driven by a 3½-h.p. motor.

For handling machines and other loads on the well deck and for serving the stowage holds, two 5-ton electric overhead travelling cranes are provided running on girders indicated in Fig. 2. These cranes can hoist at 30 ft. per minute and travel at 200 ft. per minute, while the cross-travelling speed of the trolley is 100 ft. per minute. Two jib cranes are also mounted, one on each side of the ship for raising seaplanes from the water or for lifting aeroplanes or other loads from a quay or lighter. One of these cranes is shown in each of the illustrations.

The storage of the large quantities of petrol required for replenishing the tanks of aircraft is an innovation in vessels of the United States Navy, and considerable foresight has been exercised in order to reduce the risk of fire. There are two petrol tanks located forward of the aircraft stowage holds, as indicated in Fig. 2, and these tanks, which extend from the inner double bottom to the main deck level, are each capable of holding 125,000 gallons. Forward of the tanks are two void spaces separated by a longitudinal bulkhead, that on the port side being utilised as a petrol pump room, while aft of the tanks is a cofferdam holding 37,000 gallons of fresh water, which serves to insulate the petrol tanks from the aircraft storage hold. The double bottom below the petrol tanks and also below the void spaces and cofferdam, are also filled with fresh water, and a small quantity of fresh water is also kept on the deck above the void spaces to prevent the possibility of sparks igniting any vapour that might be produced by leakage. The void spaces are ventilated by an electrically-driven fan, the motor of which is enclosed in a watertight compartment near the after end of the forecastle; a separate motor similarly enclosed, is also provided for the ventilation of the pump room.

THE UNITED STATES AIRCRAFT CARRIER "LANGLEY."

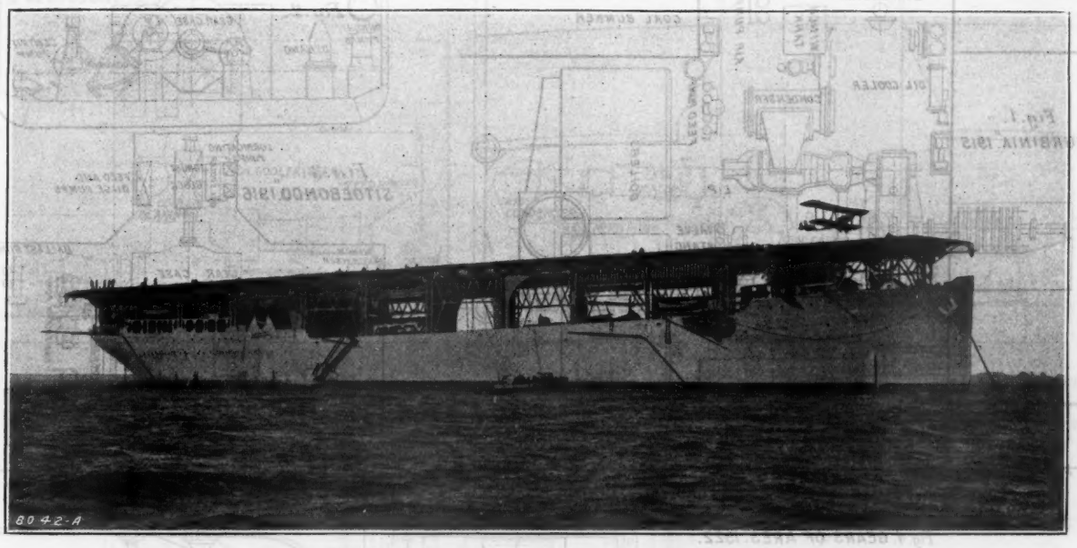


FIG. 1. AEROPLANE TAKING-OFF FROM THE DECK.

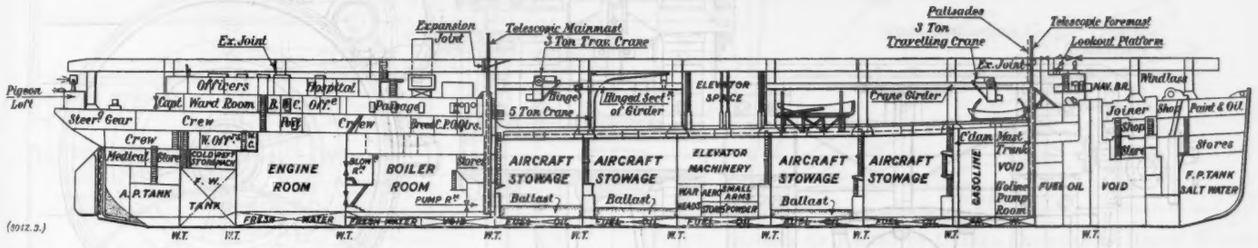


FIG. 2. LONGITUDINAL SECTION OF VESSEL.

Steam smothering valves are fitted on each tank for use in the event of an outbreak of fire.

The petrol tanks are filled by 6-in. lines which lead from flanges on each side of the ship, a 6-in. outboard valve being provided in addition to individual 6-in. valves to each tank. The depth of petrol in the two tanks can be equalised by means of the suction lines to the pump, which may be interconnected. Petrol can be drawn from any level in either tank by opening the valve for that level from the deck connection and closing the valves to the other levels. The pump discharge piping is also arranged above the deck so that petrol can be drawn from one level and returned at a different level in order to promote circulation and cool that near the top of the tank. There are four separate suction valves at different levels in each tank, and each valve can be operated independently from the main deck. Recording gauges, located on deck, are provided to show the temperature of the petrol and the pressure of the vapour in the tanks at all times. From the tanks the petrol is delivered by the pump, which is of the vertical duplex type, to supply stations located at intervals on the port side of the main deck, poop and flying deck; a station is also provided at the after end of the poop deck for supplying petrol to seaplanes afloat. The supply stations on the flying deck are covered by flush hatches beneath which there is sufficient space for coiling up a petrol hose. Each station on the main deck has a 2-in. connection as well as a $\frac{3}{4}$-in. hose connection.

Lubricating oil is carried in four tanks situated below the level of the elevator machinery deck, two of these tanks holding 7,400 gallons each and the other two 8,400 gallons each. Two 5-h.p. motor-driven pumps of the elevator machinery deck draw the oil from any of these tanks and deliver it to any of the supply stations for lubricating oil, of which there are three on the main deck and three on the flying deck. A tank with a steam heating coil is located near the oil pump, so that the oil can be heated, if necessary, before it is discharged to the supply stations.

The Langley carries four 5-in. 51-calibre guns, one mounted on each side of the forecastle and one on each side of the poop deck; all guns are equipped for individual control only. Below the elevator flat, on the starboard side, stowage space is provided for 275 aeroplane bombs of different types. The ammunition for the 5-in. guns on the forecastle is stored in a magazine close to the bomb stowage space, while that for the after guns is stowed on a specially constructed flat in what was formerly the after trimming tank. On the port side of the space below the elevator flat is a room used for the stowage, charging and overhauling of aeroplane torpedoes. In this, space is provided for stowing 24 torpedoes, and there is a separate war-head compartment adjacent. Two air compressors are installed, one in the torpedo room and the other on the deck above. One of these compressors is capable of supplying air at 3,000 lb. per square inch and the other at 2,500 lb. per square inch, and either may be used for torpedo charging or for operating the launching catapults above referred to. The air for these purposes is taken from receivers of 185 cub. ft. capacity located on the after bulkhead of the elevator compartment.

For effecting the necessary repairs to aircraft and aero engines, the vessel is provided with a well-equipped machine shop, a small foundry with an oil-fired cupola, an electrical workshop, and a joiners' shop. Special facilities for photographic work are also provided, the equipment being probably more comprehensive than that of any other vessel. It is intended particularly for taking stationary and kinematograph pictures of machines landing on or taking off from the flying deck in order to study their movements in detail. Ultra-rapid kinematography is used for this work and will doubtless yield some extremely interesting results. The equipment includes all the apparatus necessary for taking, developing, printing and exhibiting the films.

Wireless equipment, both for the ship and for the aircraft, is carried, the ship's installation including direction-finding apparatus. For use when the masts which support the main aerial are lowered, an aerial is supported on two booms, 39 ft. long, extending from the sides of the ship at the level of the well deck and set at an angle of 45 deg. A meteorological laboratory is installed on the ship, and the two meteorologists carried issue daily bulletins of the weather from the point of view of aviation. The use of carrier pigeons in connection with naval aeronautics is now being studied, and for this purpose a house capable of accommodating 48 birds is mounted on the poop deck at the stern of the vessel.

From the foregoing general description of the vessel in which we have only been able to refer briefly to some of her more important features, it will be evident that while the ship herself would not be capable of serving with the fleet in a naval engagement she is likely to serve her purpose extremely well in providing data for the design of future aircraft carriers, and experience for the personnel required to man them.

MINE RESCUE PARTIES TRANSPORTED BY AIR.—The United States Department of the Interior is experimenting at Birmingham, Alabama, with the use of aeroplanes for transporting rescue crews to mines at which accidents require their services. In a recent test two aeroplanes carried five sets of oxygen-breathing apparatus a distance of 60 miles in 46 minutes, with two Bureau of Mines engineers, landing safely at Carbon Hill, a coal-mining town. The Bureau of Mines at present maintains 10 railway cars and seven motor wagons equipped with mine rescue apparatus, but it is considered that for any of these to have reached the same spot, would have taken at least 3 hours on the railway, and quite 4 hours by the public roads.

THE BAKU OIL INDUSTRY.—The Baku oil industry which has now for over three years been in the possession of the Soviet, is being resuscitated. During the early months after the transfer the production receded very materially, from various reasons, such as lack of organisation, wilful sabotage, &c. An improvement set in with the beginning of 1921. For the year from May, 1921 to 1922, the production amounted to 2,799,000 tons, and the output for the corresponding period 1922–1923 is stated to have been 3,340,000 tons. In November, 1920, only 618 wells were being worked. In May, 1923, the number of wells working had reached 1,650. The feet bored between May, 1920, and May, 1921, aggregated 9,100; for the next twelve months the total was 37,900; and for the period May, 1922, to May, 1923, 105,000 ft. The number of men employed in this industry had risen to 45,687 hands at the end of May, 1923. Apart from the productive work proper, extensive repair work has been proceeding on factories, railways and workmen's dwellings.

STEAM TURBINES FOR MARINE PROPULSION IN HOLLAND.

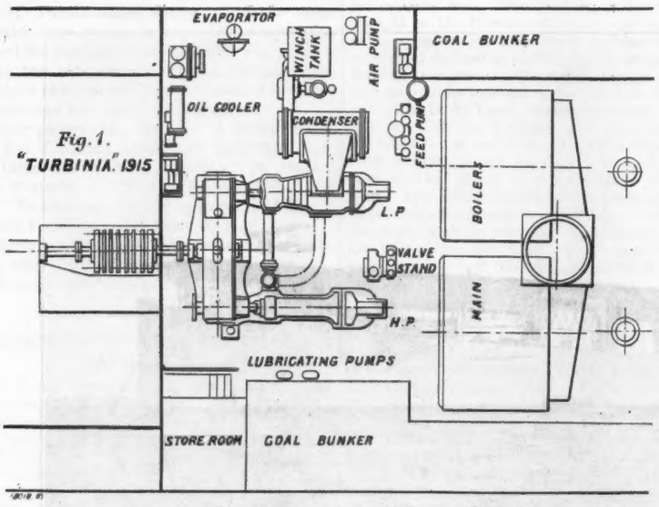
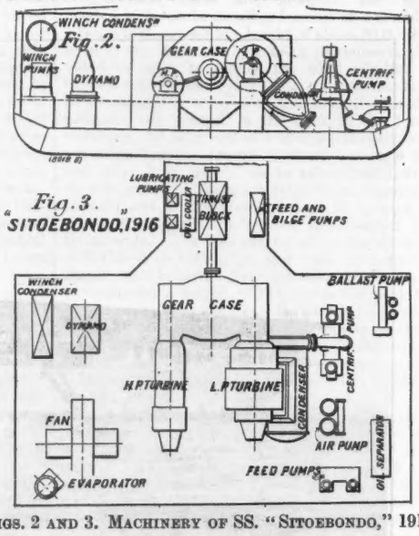


FIG. 1. MACHINERY OF SS. "TURBINIA," 1915.



FIGS. 2 AND 3. MACHINERY OF SS. "SITOEBONDO," 1916.

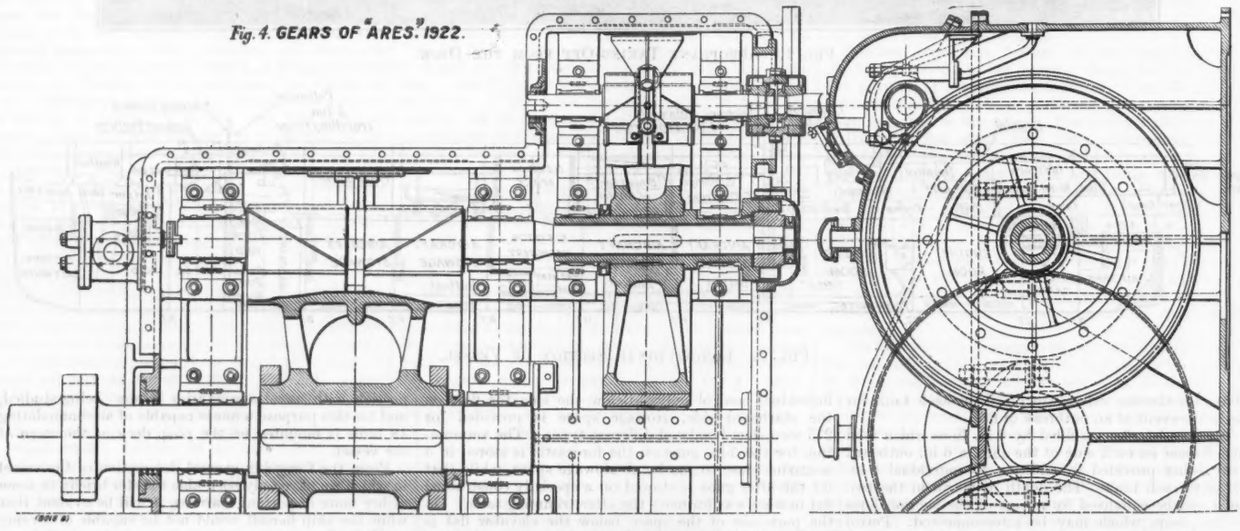


FIG. 4. DOUBLE-REDUCTION GEAR OF SS. "ARES," 1922.

STEAM TURBINES FOR MARINE PROPULSION IN HOLLAND.*

By Professor D. DRESDEN, of The Hague.

IN 1915, for a meeting of the International Engineering Congress in San Francisco, the author had the pleasure of presenting a short paper on "The Development of the Construction of Turbines in the Netherlands." In concluding that paper, the author stated that, up to that time, no marine turbines had been built in Holland, but that "at present, however, one of our chief steamer lines has placed an order for a turbine-driven steamer with Netherland firms."

Between the time of writing that statement and the present meeting hardly more than eight years have elapsed, and it may be interesting to note how matters have progressed in this period. The first turbine steamer built in Holland, the one referred to in 1915, was the Turbinia, belonging to the Rotterdamsche Lloyd, of Rotterdam, and built by the Rotterdamsche Droogdokmaatschappij of the same city. The arrangement of her machinery is shown in Fig. 1. Apart from a few small powered gears in launches, &c., the first geared transmission was built for the Vespasian in 1909-10, and although some other installations were built soon after, practical experience with geared turbines was still rather limited at the time when the Rotterdamsche Lloyd decided to adopt this type of drive. It is gratifying to see that time has proved the soundness of judgment of the directors and technical experts of this company. The turbines for this first ship were built by the Rotterdamsche Droogdok to the designs of the

* A paper read at the Summer Meetings of the Institution of Naval Architects held in Holland, September 5, 1923.

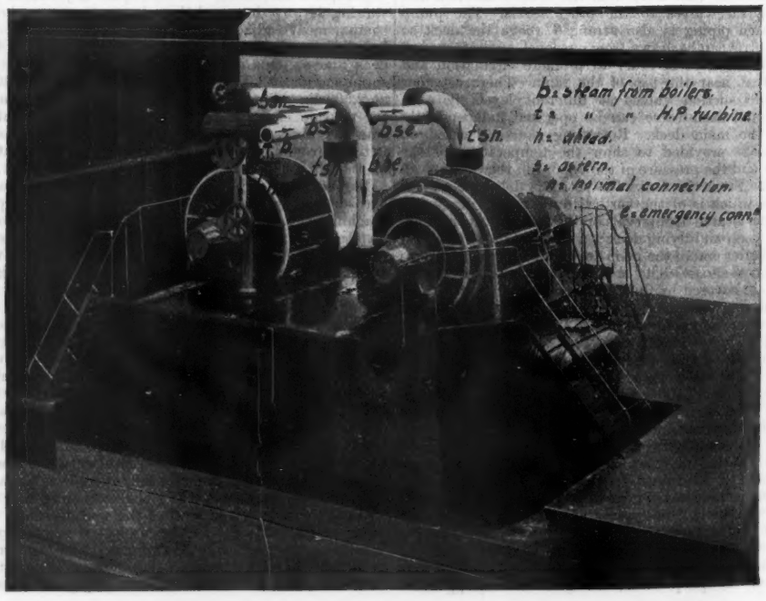
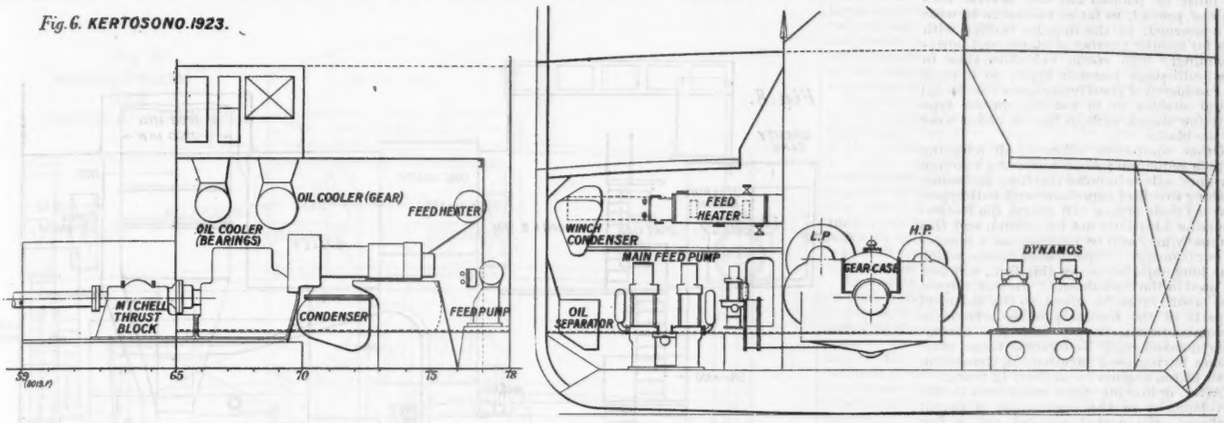


FIG. 5. SMALL SCALE MODEL OF THE GEARED TURBINES OF SS. "ARES," 1922.

STEAM TURBINES FOR MARINE PROPULSION IN HOLLAND.

Fig. 6. KERTOSONO. 1923.



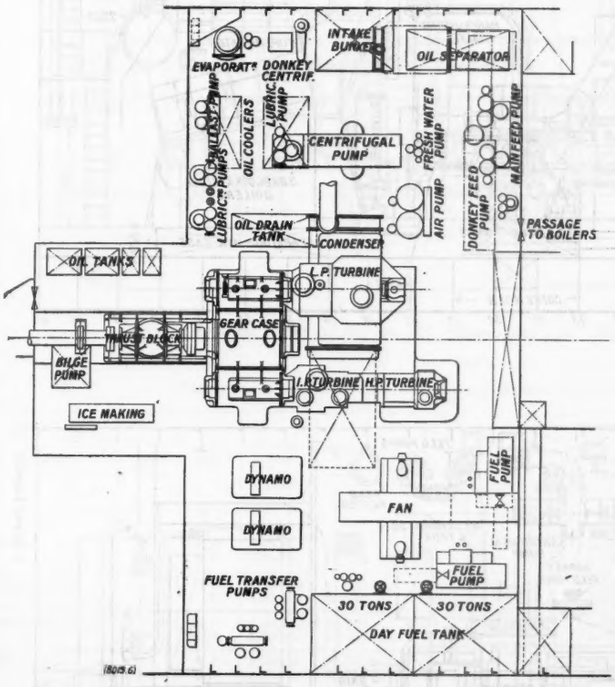


FIG. 6. MACHINERY OF SS. "KERTOSONO," 1923.

Fig. 7.

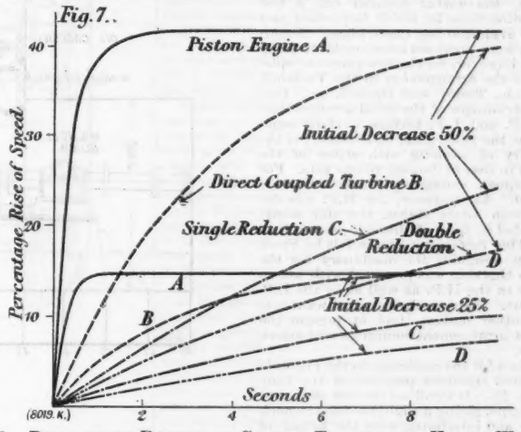


FIG. 7. DIAGRAM OF RACING OF GEARED TURBINES IN HEAVY WEATHER.

Parsons Marine Steam Turbine Company and the blades were made and fitted by this company, who also made the gears (single reduction). It was natural that we should look to England for assistance in these matters as this was the country possessing the most valuable experience at that time. This ship of 1,000 s.h.p. at 9½ miles gave satisfaction from the very first day. Trials were run on July 24, 1915, and from the first trip, when heavy storms were met, it was reported that the ship was much easier to handle, as the engines did not race and speed could easily be maintained, so as to keep the vessel under control. By comparison with sister ships, propelled by reciprocators, it was found that about 10 per cent. of fuel was saved by the turbine ship (saturated steam in all cases), and the owners considered the results so satisfactory that the geared turbine drive was adopted for further freighters and passenger ships.

The same type of turbine (Parsons marine), with the addition of the impulse wheel and single reduction, was adhered to in two freighters, Sitoebondo and Garoet, of 3,500 s.h.p. at 10½ miles. The arrangement of the machinery in the Sitoebondo is shown in Figs. 2 and 3. For the first mail steamer, the Patria, the same installation was practically doubled, comprising two H.P. and two L.P. turbines, working on two propeller shafts, developing 7,000 s.h.p. (in the aggregate) at 15 miles.

These three vessels were entirely built by de Schelde, of Flushing. This firm had taken out a licence from the Parsons Marine Steam Turbine Company as early as 1903, but did not make use of it until the building of the above-mentioned installations. As for the gears, owing to war conditions, the building firm had to make use of a set not hobbed by that firm; these gears were not satisfactory, owing to errors in pitch and in adjustment. After these poor gears had been taken out and replaced by accurately finished sets, made by de Schelde, no troubles were experienced. At present, all gears required in connection with turbine drives are entirely made at the works of de Schelde.

In order to be able to compare different types of steam turbines from their own experience, the Rotterdamsche Lloyd also procured two freighters with Zoelly steam turbines and single-reduction gears. The machinery for these ships was built by the Fijenoord Company of Rotterdam, under a licence from Escher Wyss et Cie., of Zurich. The gears were made by the Power Plant Company, of West Drayton.

These ships, Tosari and Djambi, were put into service in 1919. As a remarkable coincidence it may be mentioned that the Tosari also met with terrific storms on her maiden voyage, and broke two blades of the propeller off Honolulu. Here, once more, the geared turbines proved a success, although in the author's opinion the disc type of turbine is better suited for double reduction with higher turbine speeds and smaller diameter of the discs.

The 5 per cent. nickel steel blading, used in the Tosari and Djambi, did not give such complete satisfaction as the standard Parsons blading. It may be recalled that all these ships have saturated steam. Some corrosion of the blades was also found in the astern turbines of the Metropolitan-Vickers-Rateau installation in the Klipfontein of the Holland-South Africa Line. The question of material for blades will be referred to later in this paper. Other companies followed the example set by the Rotterdamsche Lloyd and adopted the geared turbine drive. Particulars of the ships connected with this development are given in the tables which are reproduced on pages 347 and 348. Some typical instances, however, must be mentioned.

As the double reduction allows the use of a high-speed turbine, this type was advocated from the first by Stork Bros., of Hengelo, who had been building stationary turbines under a licence from Escher Wyss et Cie. since 1906, including several large high-speed units. So a double-reduction installation was built by them for the Ares of the Koninklyke Nederlandsche Stoombootmaatschappij, of Amsterdam, developing 1,800 s.h.p. at 11 miles. This ship was also provided with Babcock and Wilcox water-tube boilers (built by Stork Bros. as licensees for Holland), and steam was superheated up to a total temperature of 300 deg. C.

The Rotterdamsche Lloyd having been the first to adopt geared turbines was the only company to use single reduction; all other companies coming later simply missed that stage, and it well illustrates the rapidity of the developments in this line that a complete phase of it started and became practically obsolete in about eight years.

The Koninklyke Nederlandsche Stoombootmaatschappij already possessed considerable experience with the use of superheated steam in reciprocating engines, and so they did not object to its use in the turbine installation. The gears were entirely made in the shops of Stork Bros., and show a very important feature in the intermediate shafts. From Fig. 4 it will be seen that the connection between the intermediate pinion and the wheel is flexible, just as in the case of the shaft between the turbine and the high-speed pinion. This arrangement allows for slight irregularities in speed and pitch, due to any cause. From the data given in the table on page 347 the load in pounds per inch of face of the teeth is calculated at 515 for the high-speed pinion and 915 for the low-speed. The "power constant" of MacAlpine* (reducing the figures to his standard pinion of face = twice the diameter for each helix) works out at 2·6. Although these loads are not excessive, they may be regarded as fairly high, and the author believes that the flexible connection in the intermediate shaft is largely responsible for the satisfactory results obtained with these gears. From the paper read by Sir Charles A. Parsons at a recent meeting of this Institution, it may be inferred that Stork Bros. were in good company in introducing this novelty. There was practically no noise whatever, and the teeth were found to be in perfect condition every time they have been inspected since the ship was put into commission in January, 1922. The author believes that more is to be gained by introducing a flexible element in the gearing than by trying to tune the whole system into a nodal arrangement, where the entire gear is kept rigid.

The blading of the turbines in the Ares was made of Monel metal, and this material, which had already been used by Stork Bros. for land turbines working with very corrosive steam, gave complete satisfaction in the Ares as well as in every other case where it has been put to use. Not the slightest sign of wear or corrosion was found on opening the turbines after a full year's service. It was stated above that no wear was found in the

* "ENGINEERING," Vol. ciii, page 321.

standard Parsons blades; here one slight reservation must be made concerning the impulse wheel, where some wear developed. It must be pointed out that severer conditions prevail, as far as resistance to wear is concerned, in the impulse turbine with the far smaller number of stages and correspondingly high steam velocities than in the multi-stage reaction type; so it must be considered of great importance that Monel metal enables us to use the impulse type with few stages, without fear of undue wear in the blades.

Other companies followed, all adopting double reduction; some preferring reaction turbines, others impulse turbines, and some, wishing to collect experience with both types, divided their orders. Of course the Rotterdamsche Lloyd did not lag behind, and this company may still be regarded as a pioneer in our country. Superheated steam, which was long objected to by this firm, will now be used in the Soekaboemi. In this respect due credit must be given to the technical experts of the Koninklyke Nederlandsche Stoombootmaatschappij and the Stoomvaartmaatschappij Nederland, these companies having used superheat in connection with piston engines for at least 12 years.

After indicating some milestones in the development of the application of geared turbines, the author pointed out a few special directions in which important and positive evolution had taken place. Astern turbines were provided from the first, being limited, however, to the low-pressure side. This was the arrangement in the Turbinia, Sitoebondo, Tosari, and Djambi, &c. One of the advantages of the usual arrangement, with H.P. and L.P. turbine working separately on the main gear, undoubtedly is the possibility of working with either of the turbines in case of damage to one side. For this purpose, emergency connections were provided. As, however, the H.P. side did not contain astern stages, the ship would be crippled in case of disaster to the L.P. side. This inconsistency was felt by Stork Bros. in designing the machinery for the Ares, so this ship was provided with astern turbines in the H.P. as well as in the L.P. main part. Apparently the same want was felt by other makers, and at present the standard arrangement comprises two astern turbines.

The place for the condenser in the Turbinia represented standard practice at the time (see Fig. 1). It involved the use of a connecting pipe, giving a slight increase in back pressure and interfering with the lifting of the top part of the L.P. casing for inspection of the interior parts. Fig. 2 of the Sitoebondo shows an improvement necessitating a somewhat high level for the turbine shafts; this can be neutralised in the design of the gear-case. A still further lifting of the turbines became possible on the introduction of double reduction, and Fig. 5 shows the arrangement in the Ares, largely influenced by the land practice of the builders. The platforms are so arranged that all auxiliaries are visible from the main platform and every part of the machinery easily accessible. (The illustration is taken from a photograph of a model of the installation.) The same place for the condenser is to be seen in Fig. 6, illustrating the Kertosono, one of the latest freighters with double-reduction gear and Parsons turbines.*

The arrangement of pipe connections has also changed, resulting in easier lifting of the top part of the turbine casing. The emergency connections are no longer permanently in place and shut by valves, but it was recognised that it is enough to fit them during the erection of the machinery so as to ensure a quick fixing in case of need. After these pipes have been given the right shape, they are put aside as spare parts, leaving more room for the regular connections and for attending to the machinery. This evolution may also be studied from the illustrations to this paper.

Although the experience of our shipping companies with geared drives is still limited, and especially as the double reduction has only been in use for about two years, it has to be mentioned that they are *all* very satisfied with the overall economy, including fuel economy as well as reliability and repair bill. As for the fuel consumption only, the author received comparative figures from the Rotterdamsche Lloyd, covering six freighters with triple-expansion engines, having made 14 voyages each (on an average), and four sister ships with single-geared turbines having made five voyages each. The average daily coal consumption, reduced to same speed and displacement, is slightly in favour of the reciprocators, the

* It may be interesting to compare the arrangement for the Reggestroom with Zoelly type turbines (Figs. 8 to 10), this ship being built by Fijenoord.

STEAM TURBINES FOR MARINE PROPULSION IN HOLLAND.

Fig. 8.

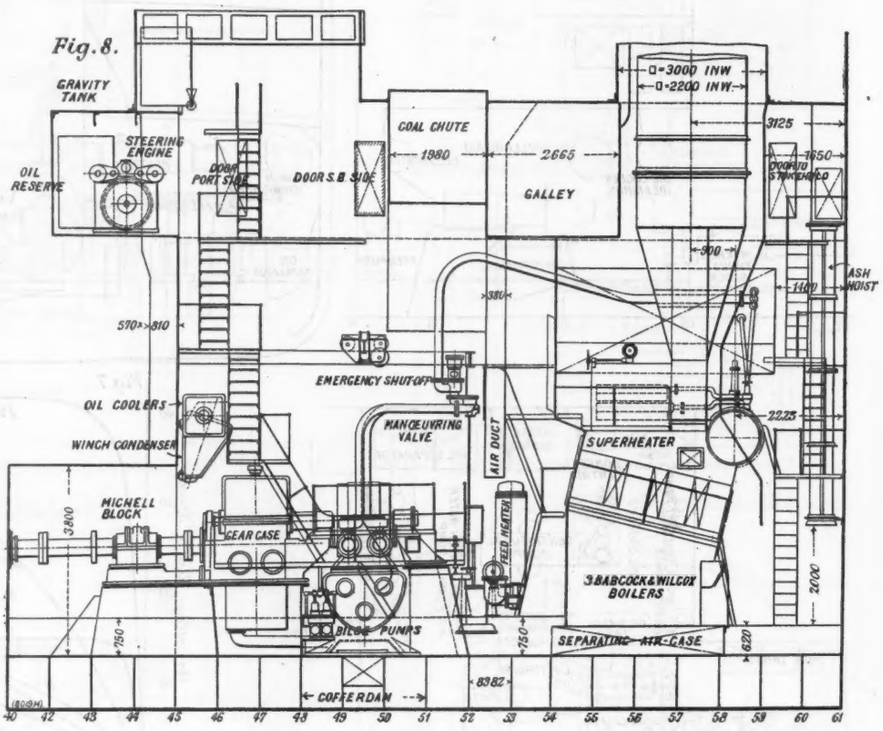
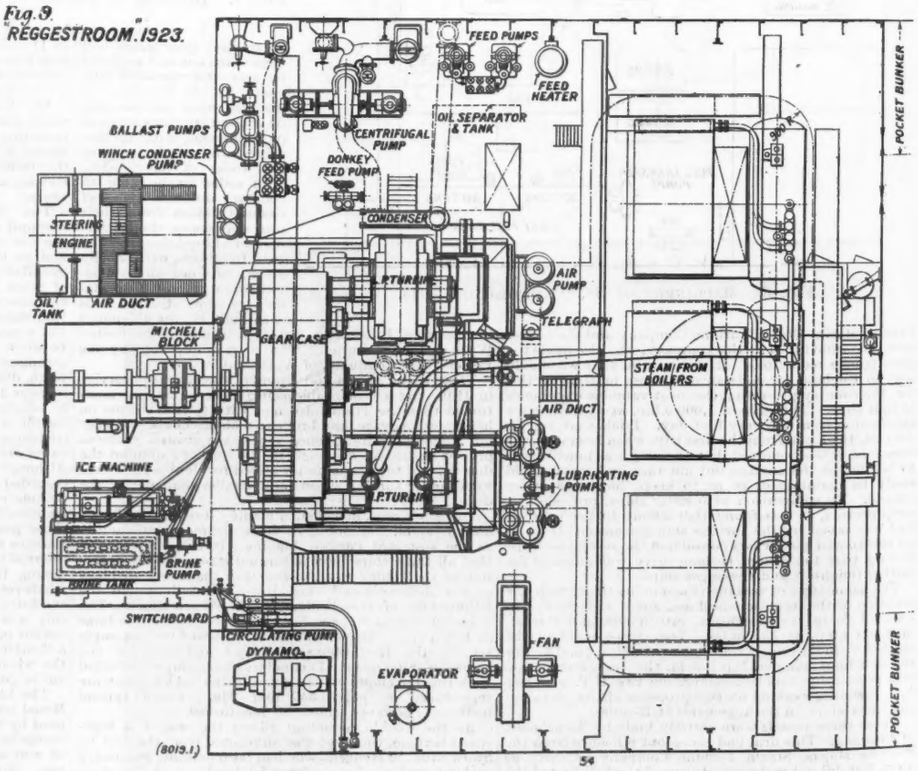


Fig. 9.
"REGGESTROOM." 1923.



FIGS. 8 AND 9. MACHINERY OF SS. "REGGESTROOM," 1923.

TURBINES FOR MARINE PROPULSION IN HOLLAND.

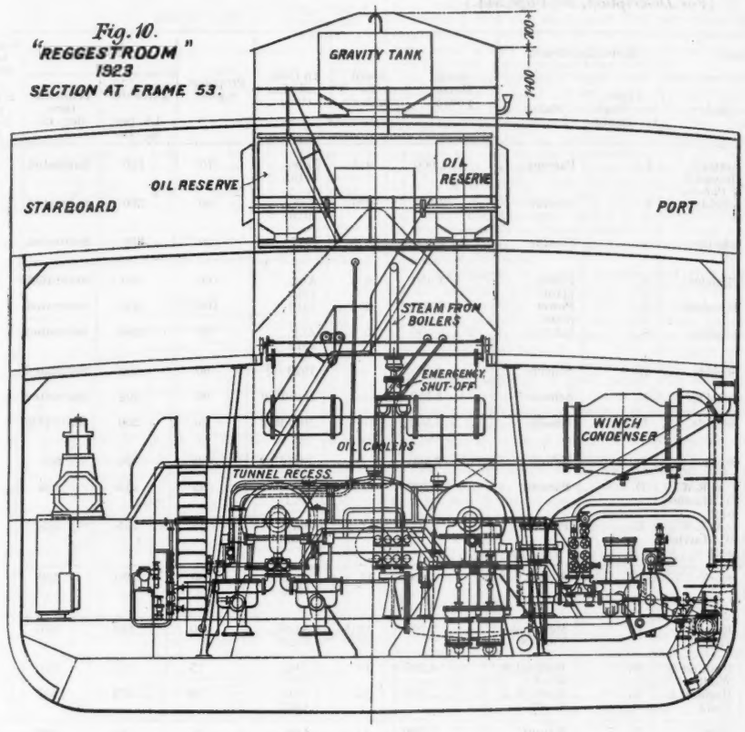


FIG. 10. MACHINERY OF SS. "REGGESTROOM," 1923.

PARTICULARS OF REDUCTION GEARING OF MARINE TURBINES.

Steamer.	Reduction.	Side.	Revolutions per minute.	Number of teeth.	Pitch Line Diameter.		Effective width of face.	Normal pitch.	Speed on pitch line.	Load at Full speed.	Specific load at Full speed.
					Pinion.	Wheel.					
					Inches.	Inches.	Inches.	Inches.	Ft./Min.	Lb.	Lb./In.
Turbinia	—	H.P.	2,000/70	19/546	4·64	133·2	20·75	0·766	2,400	—	—
	—	L.P.	2,000/70	19/546	4·64	133·2	20·75	0·766	2,440	—	—
Sitoebondo and Garoet	—	H.P.	1,500/90	31/533	7·78	133·7	39	7/12	3,000	—	—
	—	L.P.	1,500/90	31/533	7·78	133·7	39	7/12	3,000	—	—
Tosari and Djambi	—	H.P.	2,000/100	26/520	7·37	147·3	37	0·77	3,860	17,100	465
	—	L.P.	2,000/100	26/520	7·37	147·3	37	0·77	3,860	17,000	465
Patria	—	H.P.	1,500/90	31/533	7·78	133·7	39	7/12	3,000	—	—
	—	L.P.	1,500/90	31/533	7·78	133·7	39	7/12	3,000	—	—
Kertosono	1st	H.P.	3,200/434	40/295	8·5	62·6	20	7/12	7,100	—	—
		L.P.	2,100/434	61/295	12·95	62·6	20	7/12	7,100	—	—
	2nd	H.P.	434/90	53/255	19·44	93·5	40	1	2,200	—	—
		L.P.	434/90	53/255	19·44	93·5	40	1	2,200	—	—
Slamat	1st	H.P.	3,200/434	40/295	8·5	62·6	18	7/12	7,100	—	—
		L.P.	2,150/434	59/295	12·53	62·6	18	7/12	7,100	—	—
	2nd	H.P.	434/90	53/255	19·44	93·5	34	1	2,200	—	—
		L.P.	434/90	53/255	19·44	93·5	34	1	2,200	—	—
Soekaboemi ..	1st	H.P.	3,392/481	39/275	7·75	55	15·2	0·5	6,900	6,400	420
		L.P.	3,226/481	41/275	8·2	55	15·2	0·5	6,900	5,000	325
	2nd	H.P.	481/80	69/415	19	113	38·8	0·75	2,380	18,500	475
		L.P.	481/80	69/415	19	113	38·8	0·75	2,380	14,300	370
Ares	1st	H.P.	3,588/409	38/333	6·9	60·5	10·2	0·5	6,400	5,300	515
		L.P.	3,408/409	40/333	7·3	60·5	10·2	0·5	6,400	3,850	370
	2nd	H.P.	409/80	52/266	11·7	60	27·5	0·58	1,260	27,000	920
		L.P.	409/80	52/266	11·7	60	27·5	0·58	1,260	19,800	670
Reggestroom ..	1st	H.P.	4,250/625	32/217	6·43	43·6	18	0·55	7,150	4,850	269
		L.P.	4,250/625	32/217	6·43	43·6	18	0·55	7,150	4,850	269
	2nd	H.P.	625/85	32/237	12·85	95·15	23	1·09	2,110	16,450	715
		L.P.	625/85	32/237	12·85	95·15	23	1·09	2,110	16,450	715
Singkep	1st	H.P.	3,500/400	34/299	7·2	63·5	14·2	0·5	6,600	—	—
		L.P.	2,700/400	44/299	9·3	63·5	14·2	0·5	6,600	—	—
	2nd	H.P.	400/78	48/245	17·6	90	31	0·86	1,840	—	—
		L.P.	400/78	48/245	17·6	90	31	0·86	1,840	—	—
Aalsum	1st	H.P.	3,700/440	32/269	6·8	57·3	12·5	7/12	6,600	—	—
		L.P.	2,400/440	49/269	10·44	57·3	12·5	7/12	6,600	—	—
	2nd	H.P.	440/75	44/259	16·36	96·3	32	1	1,880	—	—
		L.P.	440/75	44/259	16·36	96·3	32	1	1,880	—	—
Wolsum	1st	H.P.	3,300/423	34/265	7·2	56	10	7/12	6,200	—	—
		L.P.	3,300/423	34/265	7·2	56	10	7/12	6,200	—	—
	2nd	H.P.	423/75	38/217	14	79·87	25	1	1,550	—	—
		L.P.	423/75	38/217	14	79·87	25	1	1,550	—	—

corrections to be applied in this reduction of the figures being small. This result is not in accordance with the original saving of 10 per cent. The comparison between the mail steamer Patria and the sister ship with triple-expansion engines covering seven and 14 trips respectively, also discloses a higher economy for the reciprocators, the difference being even more pronounced and amounting to at least 10 per cent. The first voyage of the Siantar (double reduction), however, shows an advantage of 25 per cent. over the reciprocating engine!

Comparing the results of the Ares (double-reduction turbines, superheat) with the sister ships (piston engine, superheat), from two voyages of the Ares and six trips of the others, shows that the Ares made on an average 8·7 miles, against 8·35 for the others, whereas the consumption of fuel oil per mile was 67 against 73·5 kg. Reduced to the same basis, this means that the turbine ship shows a saving of 16 per cent. Seeing that this installation is of only 1,800 s.h.p., and that the ship is run with only 1,200 s.h.p., the economy of the double-reduction turbine is apparently much higher than that of the piston engine even within this range of power.

Regarding the alarming results reported now and then on double-reduction gears and geared turbines in general, it may be of service to give the opinion of the responsible technical experts of our steamship lines. They lay much stress on the advantage of geared turbines in bad weather, due to the almost complete absence of racing. This valuable property is well known, but it may be interesting to compare some typical installations from this point of view on a quantitative basis. For this purpose the author calculated the increase of speed for a triple-expansion piston engine of 6,650 i.h.p. at 75 revs. per minute, for a direct drive by Parsons turbines at 600 revs. per minute, for a geared system, H.P. and L.P. at 1,500 revs. per minute and propeller at 100 revs. per minute, and lastly, for a double-reduction system, turbines at 3,300 revs. per minute, propeller at 80 revs. per minute.

Assuming an initial reduction of 25 per cent. in the resisting torque, caused by the riding of the ship, the curves of Fig. 7 were found. Initial reduction of 50 per cent. gives the higher curves. It is evident that the piston engine will race so spontaneously that the parts are endangered; the geared turbine, and more especially the double-reduction turbine, does not reach an appreciably higher speed before the propeller has again been submerged. This inertia of the geared drive does away with the necessity of lessening speed in bad weather, and the result is an indirect, but most important, increase in the economy of the ship.

Another factor of much importance to the users is that the attention to the machinery is very simple, and that very little time is required in port to overhaul the main engines; periodical inspection of bearings and gears; cleaning the oil system now and then, and opening the turbines perhaps twice a year to inspect the interior is all that is wanted. Although all parties involved know that some difficulties will still present themselves, it may be taken for granted that in our mercantile marine the double-reduction geared steam turbine with superheat has come to stay, *i.e.*, that there will be no stepping backwards; of course, there is always the possibility that it will in its turn be superseded by the next step in the direction of progress. The author does not want to prophesy, and will be satisfied if he has succeeded in giving the reader an idea of what *has* happened and *is* happening now; it may be left to the individual reader to draw his own conclusions, and perhaps make his choice.

In concluding, the author wants to remark that he purposely left out from his survey the fast cruisers for the Government, which will be provided with direct-coupled turbines of 65,000 s.h.p. Details of these installations cannot be published, and the author does not think the arrangement sufficiently interesting or typical to digress upon it.

The author would like to express his gratitude to the firms and gentlemen who assisted in the preparation of this paper by putting at his disposal their experience, data, and the drawings of the various ships illustrated here.

THE EFFECT OF SMALL QUANTITIES OF NICKEL UPON HIGH-GRADE BEARING METAL.*

By A. H. MUNDEY, Member, and C. C. BISSETT, B.A., B.Sc., B.Met., Member, London.

THE object of this Note is to report the result of a practical investigation into the mechanical and wearing properties of a bearing metal of well-known grade after the addition of small but increasing amounts of nickel.

That it has been the practice of some engineers and manufacturers to add nickel to white anti-friction or bearing metals has been fairly common knowledge. The actual object of this, however, has been the subject of some speculation, and possible controversy. It has been largely held that the original idea was not a metallurgical or even an engineering one, in the true sense, but to provide a means of identification of a certain manufacturer's metal after the bearing had been cast and taken into service, whether with success or otherwise. The practice was adopted in other quarters, thus destroying the original object of providing an identification or distinguishing sign, and as really excellent alloys were so treated, and as good results in running were obtained, some virtue gradually became attributed to the nickel content. Whether this story be true or not the authors cannot say, but it certainly obtained much credence in interested engineering circles.

No reliable evidence, however, appears to exist as to

* Abstract of a paper read at the meeting of the Institute of Metals, Manchester, on 11 September, 1923.

PARTICULARS OF TURBINE-DRIVEN STEAMERS BUILT IN HOLLAND.

(*For Description, see Page* 344.)

Owners.	Steamer.	Type of Vessel.	Turbines. Type.	Turbines. Maker.	Reduction Gears. Type. S = Single D = Double	Reduction Gears. Maker.	Shaft Horse-power.	Speed in miles.	In Commission since	Propeller. r.p.m.	Steam. Pressure. Lb. per Sq. In.	Steam. Temperature, deg. C.	Guaranteed steam per S.H.P. per hour. Lb.
Rotterdamsche Lloyd ..	Turbinia	Freighter ..	Parsons impulse reaction	Rotterd. Droogdok & Parsons	S. ..	Parsons ..	1,000	9·5	July, 1915.	70	180	Saturated	—
	Sitoebondo ..	Freighter ..	Parsons impulse reaction	Schelde ..	S. ..	Schelde ..	3,500	10·5	Dec., 1916	90	200	Saturated	—
	Garoet	Freighter ..	Parsons impulse reaction	Schelde ..	S. ..	Schelde ..	3,500	10·5	1917	90	200	Saturated	—
	Tosari	Freighter ..	Zoelly impulse	Fijenoord ..	S. ..	Power plant	3,300	12·5	Aug., 1919	100	200	Saturated	—
	Djambi	Freighter ..	Zoelly impulse	Fijenoord ..	S. ..	Power plant	3,300	12·5	1919	100	200	Saturated	—
	Patria	Mail twin-screw	Parsons impulse reaction	Schelde ..	S. ..	Schelde ..	2 × 3,500	15	Aug., 1919	90	200	Saturated	—
	Kertosono	Freighter ..	Parsons reaction	Schelde ..	D. ..	Schelde ..	4,500	—	1923 (?)	90	200	Saturated	—
	Tapanoeli	Freighter ..	Parsons reaction	Schelde ..	D. ..	Schelde ..	3,750	—	Building	95	200	Saturated	—
	Slamat	Mail twin-screw	Parsons impulse reaction	Schelde ..	D. ..	Schelde ..	2 × 3,500	—	Building	90	200	Saturated	—
	Soekaboemi ..	Freighter ..	Zoelly impulse	Stork ..	D. ..	Krupp ..	2,400	—	Building	80	200	300	9·3
	Siantar	Freighter ..	Parsons impulse reaction	C.M.E.W., W. Hartle-pool	D. ..	Parsons ..	3,300	11·5	Dec., 1921	85	215	225	—
	Modjokerto ..	Freighter ..	Parsons impulse reaction	C.M.E.W., W. Hartle-pool	D. ..	Parsons ..	3,300	11·5	July, 1922	85	215	225	—
Koninklyke Nederlandsche Stoomboot-maatschappij	Ares	Freighter ..	Zoelly impulse	Stork ..	D. ..	Stork	1,800	11	Jan., 1922	80	200	300	9·75
Holland-South Africa Line	Klipfontein ..	Passenger & Freight	Rateau ..	Metropol.-Vickers	D. ..	Metropol.-Vickers	3,200	12·5	April, 1922	80	180	340	9·46†
Holland-America Line ..	Maasdam* and Edam	Passenger & Freight	Brown-Curtis	Harland & Wolff	D. ..	Harland & Wolff	4,200	13	Aug., 1921	75	215	300	—
	Beemsterdijk*	Freighter ..	Brown-Curtis	Harland & Wolff	D. ..	Harland & Wolff	3,300	12	June, 1922	75	215	300	—
Hollandsche Stoombootmaat-schappij	Jaarstroom ..	Passenger & Freighter	Zoelly impulse	Stork ..	D. ..	Krupp ..	1,300	11	Oct., 1922	85	200	300	10·6‡
	Reggestroom	Passenger & Freighter	Zoelly impulse	Escher Wyss & Cie.	D. ..	Power plant	2,100	11·7	1923	85	215	300	—
Stoomvartmaat-schappij Nederland	Singkep	Freighter ..	Parsons impulse reaction	Werkspoor	D. ..	Werkspoor	2,400	11	Building	78	180	300	9·15
	Soemba	Freighter ..	Zoelly impulse	Stork ..	D. ..	Krupp ..	2,400	—	Building	80	200	300	9·35
Stoomvaartmaat-schappij Oostzee	Wolsum	Freighter ..	Parsons impulse reaction	Schelde ..	D. ..	Schelde ..	2,000	—	1921	75	180	Saturated	—
	Aalsum	Freighter ..	Parsons impulse reaction	Schelde ..	D. ..	Schelde ..	2,750	—	1922	75	200	Saturated	—
Stoomvaartmaat-schappij Hillegersberg	Hardenberg ..	Freighter ..	Parsons impulse reaction	Schelde ..	D. ..	Schelde ..	1,350	—	1922	70	200	Saturated	—

* Total fuel (oil) consumption, 1 lb. per S.H.P. per hour. † At 2,200 S.H.P., total coal consumption 1·85 lb. per S.H.P. per hour. ‡ During first trip, at only 950 S.H.P., measured 10·8 lb.

whether nickel in the small quantities usually found in these alloys played any useful part or not. Nor is there, to the knowledge of the authors, any reports of tests or experimental investigations available on the subject. The authors therefore decided to make a number of trial ingots of a thoroughly well-tried and reliable alloy, which is justly valued on account of its excellent mechanical properties, mainly its toughness, whilst it still possesses a very high and well-deserved reputation as a bearing metal. The alloy chosen was :—

Tin, 93 per cent. ; antimony, 3·5 per cent. ; copper, 3·5 per cent.

This alloy was reported upon by the authors in their paper on "White Metals," which was submitted to the Institute at the Autumn Meeting in 1922.* The test results are given in Table I :—

TABLE I.—*Test Results.*

Tensile Test. Tons per Sq. In.	Tensile Test. Elongation per cent. on 2 in.	Brinell Hardness Number. 10-mm. Ball, 500 kg.	Compression Test. Tons per Square Inch. Yield Point 0·001 In.	Compression Test. Tons per Square Inch. Compressed to Half-Length.
5·12	11·6	24·9	3·569	14·732

For the purposes of the present trial a number of batches of this alloy were taken, in which 0·1, 0·2, 0·3, 0·4 and 0·5 per cent. of nickel were included, in each case the nickel being made to replace a corresponding amount of tin, so that the antimony and also the copper content remained constant. In addition a further cast of metal containing 1 per cent. of nickel was made, but this also contained 4 per cent. of copper and 3·5 per cent. of antimony.

The greatest care was taken in order to ensure the correctness of composition, and the results were checked by analysis. The nickel was introduced in the form of cupro-nickel—20 per cent. nickel, 80 per cent. copper. The test-pieces for every test were cast under the most uniform conditions possible, and every precaution was taken to treat each batch similarly. The tensile and other test-pieces were poured at 350 deg. C., cast into iron moulds heated uniformly to 100 deg. C.

Specimens for microscopic examination were taken from a corresponding position from each ingot.

Bearings were cast for trials on the Thurston machines in exactly the same manner, and were machined, scraped and fitted by fitters whose skill and precision of workmanship are beyond question.

The tensile test-pieces were made of the usual form 0·564 in. diameter, acting length 2 in. The Brinell test was with a 500-kg. load, 10-mm. ball. The results are given in Table II.

The compression test pieces were 0·564 in. diameter, 0·5 in. high.

The test results do not compare very favourably with the original alloy. At any rate, they do not promise advantage in any direction. The compression tests were specially disappointing ; all the specimens after taking a minute permanent set, at the loads which are given gave way completely when compressed to about 0·35 in. high, with a load of 10 tons, and sank without further loading to the heights given in the last column. The irregularity in the elongation is characteristic of alloys of this type, as they consist of a soft matrix with very hard constituents embedded. Heat-treatment tends to regularise, but it was not adopted, as it is seldom used in engineering works practice. Service conditions were aimed at.

The actual running trials were more encouraging. Each pair of bearings for the Thurston machine was tried at 25 lb. per square inch and 50 lb. per square inch, the diameter of the journal being 1·25 in., speed 1,500 r.p.m., or approximately 500 ft. per minute.

TABLE II.—*Test Results.*

Specimen Mark.	Nickel Content.	Tensile Test. Tons per Sq. In.	Tensile Test. Elongation per cent. on 2 in.	Brinell Hardness Number.	Compression Test. Tons per Sq. In. Yield point, 0·001 In.	Compression Test. Tons per Sq. In. Compressed to half-length.	Final Length.
B	0·1	4·6	18·0	19·3	2·85	..	0·235
C	0·2	4·6	12·2	21·5	2·85	..	0·223
D	0·3	4·4	6·1	22·3	2·57	..	0·25
E	0·4	4·6	11·0	21·5	3·0	..	0·218
F	0·5	3·6	5·7	21·5	3·07	..	0·242
G (Also 4·0 copper)	1·0	4·1	15·4	20·1	2·57	..	0·242

The lubrication was constant and by pad application, a high-grade lubricating oil being employed. Each trial run was taken over 100,000 revolutions, the temperature of the bearing being noted at each 1,000 revolutions, the surface pull being also noted at the same intervals. Representative curves showing the course of trials are given.

It was noticed that in the case of the alloys containing nickel the oil became rapidly blackened, evidently by early abrasion of the bearing surface. After this had occurred rise of temperature became much less marked.

* See ENGINEERING, vol. cxiv, pp. 371 and 441.

The running tests must, it is considered, be looked upon as satisfactory.

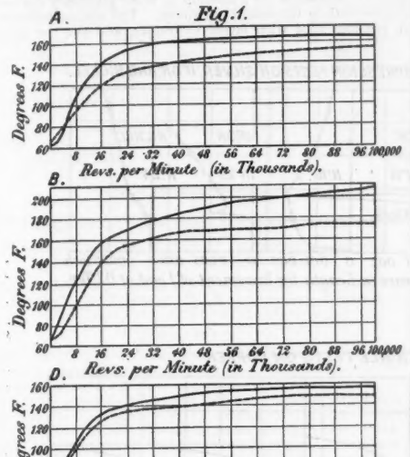
TABLE III.—*Test Results.*

	Rise per 1,000 Revs.		Surface Pull.* Average Lift Figure.	
	25 lb. per Sq. In.	50 lb. per Sq. In.	25 lb. per Sq. In.	50 lb. per Sq. In.
A. Original alloy.. ..	0·95	1·05	0·0699	0·1228
B. Nickel, 0·1 per cent...	1·08	1·39	0·1228	0·1405
D. Nickel, 0·3 per cent...	0·88	0·98	0·0963	0·1228
F. Nickel, 0·5 per cent...	0·88	1·0	0·0875	0·0875
G. Nickel, 1·0 per cent...	0·6	0·95	0·0699	0·1228
Copper, 4·0 per cent.	0;6	0·95	0·0699	0·1228

* Indicated by tangent of angle of lift of pendulum during running.

The Brinell tests were slightly lower than those obtained in the original alloy.

Fig. 1.



The comparison in the loss of hardness, due to rise of temperature, is interesting.

TABLE IV.—*Loss of Hardness due to Rise of Temperature.*

Alloy.	Temperature. 20° C.	40° C.	65° C.	90° C.	Remarks.
A. Original alloy..	24·9	24·2	23·6	22·8	Time of loading uniform, at ordinary temperatures, actually twenty seconds.
B. Nickel, 0·1 per cent.	19·3	18·6	18·1	17·4	
C. Nickel, 0·2 per cent.	21·5	20·8	20·2	19·4	
D. Nickel, 0·3 per cent.	22·3	21·6	21·0	20·2	
E. Nickel, 0·4 per cent.	21·5	20·8	20·2	19·4	
F. Nickel, 0·5 per cent.	21·5	20·8	20·2	19·4	
G. Nickel, 1·0 per cent. ; Copper, 4·0 per cent.	20·1	19·4	19·0	18·2	

The usual difficulties arise in taking the Brinell hardness of these alloys ; the crater is not perfectly circular, and the mean of several measurements under the microscope has to be taken.

The photo micrograph of the original alloy shows very strongly marked, the copper-tin compound, this being the only striking feature of the structure ; the antimony content being only 3·5, the whole of it is in solid solution in the tin. In the specimens containing even small quantities of nickel there is a great diminution in the amount and development of the copper-tin constituent, this being particularly marked in samples E and F, containing 0·4 per cent. and 0·5 per cent. of nickel respectively ; whilst in G the revival of the copper-tin compound is very evident, this being the alloy containing 0·5 per cent. more copper than the rest.

It therefore appears that the presence of small quantities of nickel have the effect of combining with or dissolving in the copper present, and that the copper-tin compound is suppressed, hence the alloy loses that valuable property of resistance to crushing which it appears to owe to the interlocking of the copper-tin compound in its dendritic form, and the hardening effect, if any, of the nickel does not compensate for the loss of this form of structure. The authors hope that workers who have had the opportunity of making investigations in pure research on these metals will correct or confirm these impressions ; at present the manufacturer is without precise information.

In conclusion, it would appear that the addition of nickel in such proportions to alloys of this character does not justify itself. No substantial advantages appear to accompany its use, and some valuable properties are diminished—unless it be that certain engineers have established faith in it. If it does give confidence, its use is in a certain measure justified. In the case of high-grade bearings of good design the stresses are not likely to be so great as to cause failure by an overload, by crushing, although vibration or knocking may have a somewhat similar effect.

The actual value of nickel in such bearing metals is, it is thought, still to be proved.

The authors desire to thank Mr. John Fry, of Fry's Metal Foundry, for permission to publish this Note and for much encouragement in carrying out the work.

THE BEHAVIOUR OF METALS UNDER COMPRESSIVE STRESSES.*

By H. I. COE, M.Sc., Member (University College of Swansea).

THE author observed during the course of some experiments on cylinders of tin and lead and their alloys that when tested in compression under regularly increasing loads the changes in height and diameter, when plotted in the form of load-strain diagrams, did not yield smooth curves during the semi-plastic and plastic ranges, but that there was a discontinuity in the curves ; the break was not readily observed when the ordinary method of graphical representation was adopted, but was shown very clearly when the difference in dimensions of the cylinder for unit increase of load was plotted against the load on the specimen. These observations led to the carrying out of compression tests on other metals, and the same phenomenon was in nearly all cases observed ; it was more marked in some metals than in others, and in the case of a particular metal more clearly defined when the sample tested was initially in a state of stress, such as that produced by rolling or drawing.

A 10-ton Buckton testing machine was employed for the application of loads to the test-pieces, which were in the form of cylinders 1 in. long and, with a few exceptions, ¾ in. diameter. Pressure was applied through polished hardened steel compression plates which were backed with thin sheet lead, by means of which true parallelism of their faces could be ensured. With certain exceptions, loads were applied in steps of 0·2 ton for a period of one minute ; after the application of a load the specimen was removed, length and diameter were measured by micrometer gauges to $\frac{1}{10,000}$ in., the specimen replaced, turned on its axis through an angle of 90 deg., and the next higher load applied. It was found that in many cases measurements of length indicated a permanent set at a considerably lower load than was indicated by the measurement of diameter ; it is thought that this permanent set was due to imperfections in the machining of the cylinders, and that the first permanent increase in diameter affords a truer indication of the elastic limit of the material having been exceeded. With Armco iron, for example, the permanent set indicated by measurement of diameter agreed with the permanent set in tension, whereas the permanent set as indicated by measurement of length in some cases did so, but in other cases occurred at a considerably lower load. Measurements of diameter are reliable except at high loads, under which, in some cases, the sides became rough and irregular. Where reference is made to tests on metals in the chill-cast condition, the cylinders had been prepared from the bottom end of ingots 3 in. long by 1 in. diameter, obtained by casting in an iron mould with walls ¾ in. thick. Stresses per square inch, where given, are calculated on the mean of the cross-sectional areas of the specimens before and after the application of the load concerned. Tensile test-pieces were prepared and tested over a parallel length of 4½ in. ; loads were applied in steps similar to those for the corresponding compression test-pieces, and were taken off prior to measurement, which was made by dividers for length, and a micro-meter gauge for diameter. Percentage elongation was determined on a length equal to $4\sqrt{\text{area}}$. Brinell hardness tests were carried out with the use of a ball 10 mm. diameter and a load of 1,000 kg. applied for one minute, except in the case of tin and lead for which it was 200 kg., and iron and nickel, for which it was 3,000 kg.

Results of Tests.—The results of tests in compression are represented graphically in Figs. 1 to 6, and an examination of most of the curves will show that the rate of flow, as measured by the change in length of the cylinders, increases with increase in load, after the elastic limits and yield points of the metals have been exceeded, up to a maximum which is represented either by a peak, or by an inflection in the curves, and that subsequently the rate of flow tends to diminish. The stresses per square inch on the initial sections of the cylinders and the stresses per square inch on the mean of the cross-sectional areas immediately preceding and after the application of the actual load corresponding to the peak or inflection in each curve have been calculated, and the results are tabulated in the paper under the headings "Stress giving critical plasticity, tons per square inch, on initial section," and "Stress giving critical plasticity, tons per square inch, on enlarged section." The term "critical plasticity" has been used conveniently to describe an abnormal change in the degree of plasticity which, according to the present experiments, most metals exhibit at a particular load. Load increase in diameter curves were drawn, and were similar in shape to the load decrease in length curves which are reproduced. The results of tensile tests and determinations of hardness and density for a number of the metals considered are also given in the paper, in table form.

The tests on each metal will be discussed briefly.

Tin.—Material used : electrolytic tin (99·99 per cent. Sn). The results of tests in compression are represented graphically in Fig. 1.

No. 1. Chill-cast tin. The compression test was carried out in connection with a different series of experiments, and the time of application of each load was two minutes, instead of one minute adopted in the present work ; the load was applied by increments of 0·1 ton.

No. 2. Cast tin reduced 50 per cent. in cross-sectional area by pressing and subsequently annealed for one hour at 100 deg. C. ; load applied by increments of 0·1 ton for two minutes.

No. 3. Material as in No. 2 ; load applied by increments of 0·05 ton for one minute.

No. 4. Material as in No. 2 ; load applied for one minute in steps of 0·05 ton, without removing the load between successive increments.

The curves drawn from the results of the three tests on pressed and annealed tin are interesting in respect of the fact that though carried out under different conditions, the calculated stresses giving critical plasticity in tons per square inch on the enlarged section of the cylinders are approximately the same. The low value for No. 4 may be explained as being due to the

Fig. 1. COMPRESSION TESTS ON TIN.

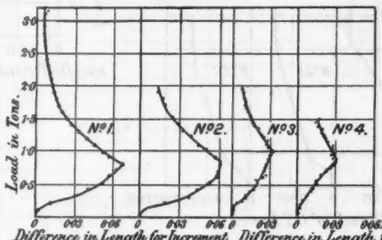

Load in Tons.
No. 1.
No. 2.
No. 3.
No. 4.
Difference in Length for Increment of Load of 0·1 Ton.
Difference in Length for Increment of Load of 0·05 Ton.
Inch.

Fig. 2. COMPRESSION TESTS ON LEAD.

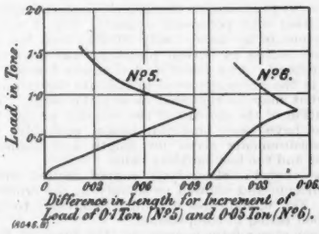
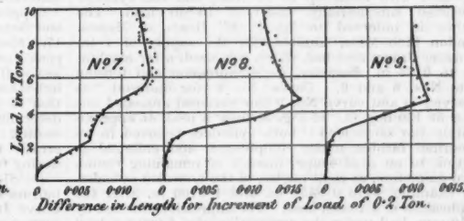


Fig. 3. COMPRESSION TESTS ON ZINC.



* Abstract of a paper read at the meeting of the Institute of Metals, Manchester, on September 11, 1923.

fact that the specimen remained in the testing machine during measurement, and accurate measurement of the diameter was a matter of difficulty on account of the roughened and irregular sides of the cylinder under comparatively high loads. A section of the results obtained from test No. 3 is given in the paper, together with the calculated stresses per square inch, on the enlarged area of cross-section, bearing at each load. It is shown that with a load of 1 ton and more, plastic deformation proceeds, though the actual stress per square inch actually falls in amount. In the test in tension the bar drew out into a narrow wedge, so no value is given to the percentage reduction in area.

Lead.—Material used: chemical lead (99·99 per cent. Pb). The curves (Fig. 2, Nos. 5 and 6) for cast lead and for lead pressed and subsequently annealed for one hour at 100 deg. C., which are drawn from the results obtained from compression tests, resemble in shape those obtained in the case of tin. In No. 5 for cast lead the time of application of the load and the increment of load, two minutes and 0·1 ton respectively, differ from those employed in test No. 6, on worked and annealed lead, which were one minute and 0·05 ton respectively. Under tensile stress the test-bar drew out to a point, so no value is given to the percentage reduction in area.

fine cracks appeared on the surface of the cylinder was equivalent to a stress of 5·45 tons per square inch; the reduction in length at this stress was 1·6 per cent.

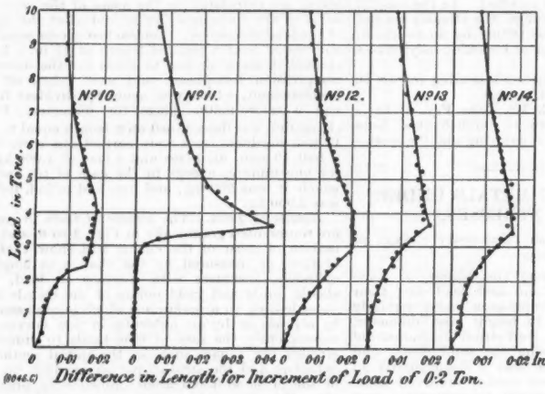
Aluminium.—Cast aluminium (99·2 per cent. Al). Fig. 4, curve No. 10. Extruded and drawn aluminium (99·6 per cent. Al) was supplied in the form of a ¾ in. diameter bar by Dr. A. G. C. Gwyer, of Messrs. the British Aluminium Company, to whom the author wishes to express his thanks. Samples from the bar were tested in the "as received" condition, and after annealing for thirty minutes at 550 deg. C. (Tests and curves Nos. 11 and 12.) Another bar, 1 in. diameter, of extruded aluminium (99·2 per cent. Al) was tested, after machining to ¾ in. diameter, under similar conditions. (Tests and curves Nos. 13 and 14.) The Brinell hardness numbers are not in good agreement with the amount of deformation undergone by the respective cylinders under the application of a 10-ton load.

Silver.—Material used: ½ in. drawn rod of pure silver. Fig. 5, curve 15, for material "as received," and curve 16 for material annealed at 800 deg. C. for thirty minutes, embody the results of tests in compression. Drawn silver exhibited a large amount of plastic flow, equivalent to 18 per cent. of the original length, on applying a load of 3·6 tons after the previous load of 3·4 tons had been taken off. This sudden yield being machined to give a parallel length of 0·505 in. diameter. These tests were carried out in the manner previously indicated, and load-difference in diameter curves are reproduced in Fig. 7, curves Nos. 19A to 22A. Curves 21A and 22A indicate the presence of a yield range in well-annealed copper, though the range of stresses does not agree with that shown in the compression tests. Further tests in compression were made on cylinders machined from the drawn bar to 0·505 in. diameter and annealed at 320 deg. C., 580 deg. C., and 800 deg. C., in order that the results could be compared with those from the tensile tests. The curves embodying the data obtained are not reproduced, as they were practically identical in general shape with those of curves 19–22, and calculated values of stresses giving critical plasticity also agreed well.

Iron, Nickel.—Armco iron annealed at 1050 deg. C., Fig. 5, curve 23. Bar (99·7 per cent. Ni) annealed at 760 deg. C., Fig. 5, curve 24.

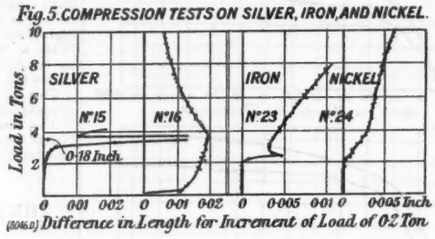
Tests were made on cylinders 0·564 in diameter. In neither case could an inflection be found in the curve after the yield point had been exceeded. Iron and nickel thus appear to be different from the other metals considered, and show no inflection in their plasticity curves corresponding to critical plasticity. The author believes it possible that with larger cylinders, and the use of a more powerful testing machine, an inflection would be found in the curves obtained from similar tests.

Fig. 4. COMPRESSION TESTS ON ALUMINIUM.



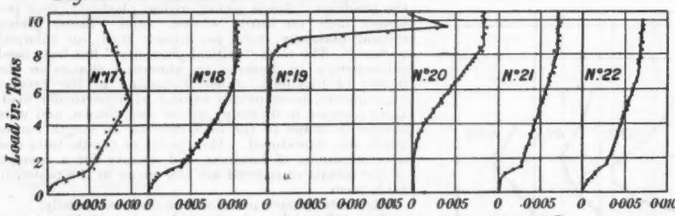
(8044.C) *Difference in Length for Increment of Load of 0·2 Ton.*

Fig. 5. COMPRESSION TESTS ON SILVER, IRON, AND NICKEL.



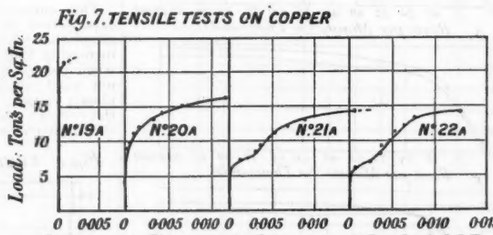
(8046.D) *Difference in Length for Increment of Load of 0·2 Ton.*

Fig. 6. COMPRESSION TESTS ON COPPER



(8045.E) *Difference in Length for Increment of Load of 0·2 Ton.*

Fig. 7. TENSILE TESTS ON COPPER



(8046.F) *Difference in Diameter for Increment of Load of 0·2 Ton.*

Zinc.—Chill-cast (99·85 per cent. Zn). The load-difference in length curve drawn from the results of the test in compression, Fig. 3, No. 7, exhibits no peak, but a change in direction at a load of 2·5 tons; no crack appeared with loads up to 10 tons, and the cylinder shortened substantially under a 10-ton load. The author is indebted to Mr. C. W. Hunn, of Messrs. London Zinc Mills, Limited, for the supply of 1 in. diameter drawn zinc bar, which was used, after machining to 0·75 in. diameter, for compression and tension tests Nos. 8 and 9. Curve No. 8 (for material "as received") and curve No. 9 (for material annealed one hour at 150 deg. C.), of Fig. 3, show a peak at approximately the same load; both cylinders behaved in an abnormal fashion under compression and enlarged in section to an oval shape, instead of remaining round. Two diameters, at right angles, of the annealed cylinder, for example, were 0·8430 in. and 1·0700 in. after the application of a 10-ton load. The impressions formed by a 10-mm. ball under the application of a 1,000-kg. load during the Brinell hardness tests were also oval in shape, two diameters for annealed zinc being 4·495 mm. and 4·994 mm.; the hardness values which were deduced for drawn and annealed zinc must consequently be regarded as approximate only. Ingall* has made a similar observation during the conduct of hardness tests on zinc. The results of tests in tension show that the elastic limit, yield point, and maximum load are unaffected by annealing at 150 deg. C., but that ductility as measured by percentage elongation and reduction in area is considerably reduced; the relative amounts of shortening of the cylinders at similar loads in compression indicate the same effect.

Antimony.—(99·6 per cent. Sb.) The metal possesses a limited degree of elasticity, and yielded slightly before minute cracks were observed on the surface of the cylinder. In compression the elastic limit was approximately 2·2 tons per square inch, and the load at which was accompanied by bending of the cylinder so that the test had to be discontinued after the application of a few further increments of load. Almost identical results were obtained with continuous loading of the same material.

Copper.—(*a*) Chill-cast: electrolytic copper melted and deoxidized with potassium cyanide. Fig. 6, curve 17. Many points lay rather badly off the curve, but the peak corresponding to critical plasticity was nevertheless well defined. At a lower load of about 1·6 ton an inflection in the curve appeared to indicate the termination of what may be regarded as a yield range. The determination of the density of the cylinder proved the casting to have been unsound, hence, probably, the erratic measurements given for length and diameter during test and the low hardness value.

(*b*) Slow cooled: electrolytic copper melted under barium chloride and allowed to solidify in the crucible. Curve 18, Fig. 6, indicates a similar behaviour to cast copper when tested in compression.

(*c*) Drawn electrolytic copper in the form of ¾ in. diameter bar. Curve 19, Fig. 6, is noteworthy as showing a relatively large temporary yield under compression at a load of about 9·8 tons.

(*d*) Drawn copper bar annealed at 320 deg. for thirty minutes. Curve 20, Fig. 6.

(*e*) Drawn copper bar annealed at 580 deg. for thirty minutes. Curve 21, Fig. 6.

(*f*) Drawn copper bar annealed at 800 deg. for thirty minutes. Curve 22, Fig. 6.

All three curves show inflections at different loads, the point of inflection tending to become less distinct with the higher annealing temperatures. Curves 21 and 22 show yield ranges similar to those displayed by cast and slow-cooled copper, and terminating at the same load, equivalent to a stress of about 3·7 tons per square inch, calculated on the original area of cross-section of the cylinder. Tensile tests were made on the drawn bar in the "as received" condition, and after annealing at 320 deg. C., 580 deg. C. and 800 deg. C., the specimens

Summary of Results and Conclusions.—The plastic deformation of tin under compressive stress has been considered in some detail, as it is representative of very soft malleable metals, which show a marked peak in the load-difference in length curve, and it has been shown that tin becomes truly plastic at a load corresponding to the peak, then stiffens slightly, but subsequently becomes perfectly plastic again. The same approach to perfect plasticity is apparently not found in the harder metals at ordinary temperatures. Excluding iron and nickel, an examination of the compression curves reproduced indicates three general types as represented by (1) the curves for tin, Nos. 1 to 4, which show a marked peak; (2) by that for drawn and annealed aluminium, No. 12, in which a marked peak is absent but which shows a very definite inflection, and (3) by that for slow-cooled copper, in which the inflection is not readily observed. The two last types were analysed with regard to the portion of the curves near the point of inflection in an Appendix, in which the stresses per square inch on the enlarged cross-sectional area of the cylinders was included opposite the various loads. In neither case is there any indication of the metal closely approaching a state of perfect plasticity at a load corresponding to the point of inflection of the curve, though in the case of copper there is a temporary increase in plasticity at that load, which corresponds to a stress of 11 tons per square inch on the enlarged cross-sectional area. With the exception of tin and lead, the metals do not become truly plastic over the range of loads employed in the experiments.

The most striking feature brought out in these experiments is the close agreement of the values for stresses giving critical plasticity calculated on the enlarged cross-sectional area of the cylinders, and the values for the maximum load in tension of the same material.

The agreement is, in general, very good; in addition, the values of stress giving critical plasticity per square inch on enlarged section for the other specimens on which tensile tests had not been made, also appear to agree well with published values of the tenacities of the metals concerned. The one exception would appear to be cast zinc, which, according to Ingall*, should be 3 tons per square inch instead of 5·54 tons, as indicated by the compression tests. It is possible, however, that the highly crystalline character of cast zinc, combined with the rela-

* See ENGINEERING, vol. cxii, pages 484 and 489.

* *Loc. cit.*

tive brittleness of the metal, may tend to yield low results when zinc is tested in tension.

It does not appear extravagant to claim that a careful study of the dimensional changes produced in cylinder of soft metals, when tested in compression, will enable fairly accurate deductions to be made of the maximum loads those metals would bear in tension.

A consideration of the reduction in length of the cylinders indicates that a maximum amount of deformation per unit of applied load is produced by the load giving critical plasticity. The determination of the reduction in length of cylinders at this load, under different conditions of its application with respect to time and temperature, may prove of value in connection with operations involved in the working of metals.

The author does not feel inclined at the present time to enter into a theoretical discussion of the mechanism of the changes which have been found to occur during the flow of metals under compressive stresses, but he believes that the results of the experiments will be of assistance in its interpretation. He desires, however, to emphasise the marked difference in the behaviour of worked and annealed metals as illustrated by the cases of aluminium, silver and copper. Worked metals, though very resistant to compressive stresses up to a certain relatively high load, appear to collapse suddenly, subsequently recovering to a certain extent their power of resistance to those stresses. The case of aluminium is interesting, as indicating that under high loads (10 tons for cylinders ¾ in. diameter) the deformation is approximately the same whatever the initial condition of the metal.

In conclusion, the author wishes to express his cordial thanks to Professor C. A. Edwards, D.Sc., who has given every opportunity for the conduct of the investigation in his laboratories.

THE EFFECTS OF OXYGEN ON COPPER.*

Investigation of the Effects of Impurities on Copper. Part I—The Effect of Oxygen on Copper.

By D. HANSON, D.Sc., Member; C. MARBVAT, B.Sc., Member; and GRACE W. FORD, B.Sc., Member. (From the National Physical Laboratory.)

INTRODUCTION.

THE present research has been undertaken with a view to ascertaining the effect of small quantities of oxygen on the properties of pure copper, and is the first portion of a more extensive research into the effect of impurities on pure copper, which is being carried out for the British Non-Ferrous Metals Research Association in the Metallurgy Department of the National Physical Laboratory, under the general supervision of Dr. W. Rosenhain, F.R.S.

This work will include, in the first place, the study of the effects of the more common impurities, one at a time. It is not possible to understand the effect of a number of impurities simultaneously present in a metal without first determining their separate effects, and the investigation of the effects of impurities one at a time must be regarded as a necessary step to the study of more complex cases. No comprehensive study of the effect of oxygen on the mechanical, electrical, and metallographic properties of pure copper has previously been made, although a large mass of unrelated information concerning the effect of oxygen on copper containing other impurities has been published. There has recently been published by Antisell a series of results expressing the effect of oxygen (up to 0·2 per cent.) on the electrical conductivity and tensile strength of copper. His raw material is described as copper of 99·97 per cent. purity, but the impurities are not stated, nor are the methods of manufacture of the alloys or the manner of annealing. His results are compared with the results of the present investigators in Fig. 1. They show that his metal is somewhat harder, and possesses a lower electrical conductivity than that used in this research. This difference may be due in part to the greater purity of the copper available for this work, but may also be due to differences in the mechanical and thermal treatment of the materials, of which Antisell gives practically no details. Throughout this research the aim of the investigators has been to eliminate as far as possible all impurities except the one under examination, and to regulate the treatment of the metal throughout in an exact manner. The conditions during casting, rolling, annealing, and other treatments have been carefully regulated and standardised, in order to render the effect of the impurity more clear.

The copper used for this investigation consisted of three cathodes supplied by Messrs. Thos. Bolton and Sons, Limited; the analyses of these cathodes are given in the Appendix, which show them to be of a high degree of purity. The method of obtaining samples for chemical analysis is also described in the Appendix, in which full details of the analytical methods are given.

In order to add oxygen to the copper, alloys high in oxygen were prepared in the following manner. Pure copper turnings were placed in a small fire-clay crucible into which a silica tube was inserted through a hole near the bottom. The crucible was placed in a gas-fired muffle furnace, heated to a temperature a little below the melting point of copper, and a stream of oxygen was passed through the copper turnings for some hours. The copper thus oxidised was then stirred into a bath of molten copper, and the metal was cast into notched moulds. This oxygen-rich alloy was carefully sampled and analysed. By this method alloys containing 0·638 to 1·55 per cent. of oxygen (5·742 per cent. and 11·97 per cent. of cuprous oxide) were obtained. Typical microstructures of these samples show that the alloys are hypereutectoid, and contain considerable quantities of free copper oxide.

CASTING.

A great deal of difficulty was at first experienced in obtaining sound castings of copper possessing a low oxygen content, on account of the very considerable evolution of gas that took place during solidification in the mould. This difficulty appeared to be specially great when the melts were carried out in salamander crucibles, which had finally to be discarded for this purpose. This action may be due partly to a reaction between the graphite of the crucible and the oxygen dissolved in the copper, with the production of gas, which is then liberated from the molten metal at the moment of solidification. Such a reaction takes place with considerable vigour between melts containing a high concentration of oxygen and the graphite crucible, and is, in fact, so vigorous as to remove oxygen rapidly from the metal and make a control of the composition very difficult. Another possible disadvantage of graphite crucibles is that they are porous, and may allow the passage of harmful furnace gases through the crucible walls; such gases react with, or dissolve in the metal, producing difficulties during casting. Contamination by sulphur from the furnace gases is another possible source of trouble in this respect.

The first experiments were carried out by using salamander crucibles and a covering of charcoal on the

Fig. 1. COMPARING ANTISELL'S AND N.P.L. RESULTS OXYGEN COPPER SERIES.

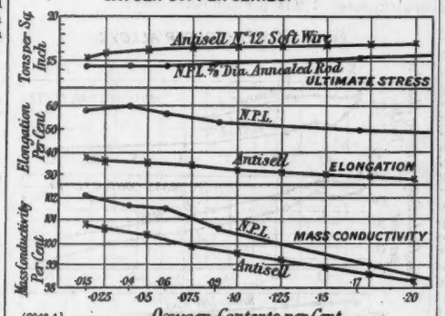
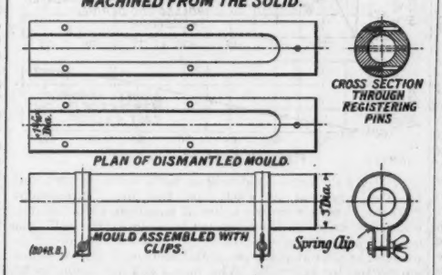


Fig. 2. 1⅜" DIAMETER GRAPHITE MOULDS MACHINED FROM THE SOLID.



molten metal, but it was found impossible under these conditions to obtain alloys containing less oxygen than about 0·04 per cent., while at the same time the castings were very unsound. It seems probable that where melting is carried out under these conditions, oxygen from the air cannot be kept from contact with the melting metal, by which it is absorbed, both before and after melting. At the same time, oxygen is no doubt simultaneously removed by the graphite of the crucible and by the covering itself. The absorption seems to be sufficiently rapid to prevent oxygen concentration falling below about 0·04 per cent. Use of a graphite crucible and a flux to cover the molten metal was tried. Borax was first used, the solid copper, cut up into small pieces, being pushed into a bath of borax, and melted under this covering. By this means, melts containing little oxygen were obtained, but they were still very unsound, and rose considerably in the mould on casting. The borax, moreover, attacked the crucibles very vigorously; the clay binder was rapidly dissolved out, while a vigorous reaction took place between the graphite and the molten borax.

Clay crucibles and a borax flux were next tried, but it was found that the crucibles were very liable to develop slight cracks, into which borax penetrated, leading to their rapid failure. A glass covering was found to be somewhat more satisfactory, since it had a much less violent action on the material of the crucible. A glass of the following composition was used:—

	Per cent.
Na_2O	3·6
CaO...	39·5
B_2O_3	12·0
SiO_2...	36·1
AL_2O_3	8·8

This covering is sufficiently fluid at the temperature of molten copper to allow additions of cold metal to be made without difficulty, while it dissolves copper oxide very rapidly.

Finally, the method found most satisfactory for these alloys was to use a salamander crucible with a clay liner, and a glass flux of the composition indicated above. The actual procedure during melting will be described later.

MOULDS.

In the first place, cast-iron moulds were used. These moulds were dressed with graphite. For a number of reasons they were found unsatisfactory. In the first place, copper containing a moderately high oxygen content attacked and removed the dressing of the mould at the point where a stream of metal hit the wall of the mould during casting, and the unprotected cast-iron surface thus produced was then attacked and dissolved by the hot metal, so that after the ingot had become solid it was found to be welded to the mould. This action is due to the rapid oxidation of the graphite coating by the oxygenated copper. A dressing consisting of lime and sodium silicate, sprayed on to the mould surface and dried, was also tried, but without successful results.

Considerable difficulty was experienced in obtaining surfaces free from cold shuts and other defects when the molten metal was poured into a cast-iron mould. Such defects rendered the metal more difficult to roll, and it was considered desirable to obtain castings having surfaces which could be rolled without being first machined.

A further difficulty was that the metal was very rapidly chilled by the heavy moulds used, and radial crystals, running from the outside surface to the centre of the ingot, were produced. Ingots in which the crystals are arranged in this manner are usually undesirable, as they are liable to break up during rolling; and it was considered necessary to devise a more suitable method of casting in which a more satisfactory structure could be obtained in the ingot. At a later stage in the investigation it was found to be difficult to avoid radial structure in high oxygen copper, but it was found possible to roll this metal without difficulty. A radial structure in this case does not seem to be prejudicial to rolling.

It may be pointed out here that the latter difficulties—namely, defective surface and deep chilling—were somewhat more serious in the present instance, in which small castings, $1\frac{3}{16}$ in. diameter, were used, than they would be if the larger ingots, such as are used in commercial practice, could have been made for these experiments. In particular, the ratio of the weight of the ingot mould to the weight of the ingot is necessarily somewhat larger in the case of a small ingot than in a large one, and the special means that have been adopted in this research will not necessarily be required when larger castings are made.

All the above casting difficulties have been satisfactorily overcome by the use of moulds machined from graphite. A drawing of such a mould is given in Fig. 2. These moulds do not chill the stream of entering metal sufficiently rapidly to form cold shuts and similar defects, so that castings can be made which possess excellent surfaces and are suitable for rolling without any machining. At the same time, graphite possesses a thermal conductivity sufficiently high to exert a considerable chilling effect on the metal. These graphite moulds are naturally somewhat more fragile than moulds made of cast iron, but unless they are handled very roughly, their life is considerable, and a large number of castings may be obtained from each. For example, some of the moulds used in the present investigation have been used for a period of several months, and have had about thirty castings made in them without serious deterioration. The reaction between the graphite and the stream of metal seems to be less violent than the reaction with the mould dressing previously used. This is possibly due to the fact that the dressing is in a fine state of division, whereas the graphite mould is more massive and has a much better heat conductivity.

Several methods of making sand castings were tried. The castings were required in the form of round bars 6 in. long by 1 in. diameter, and the following three methods of casting were tried: (1) Six rods were moulded horizontally in star-shaped form with a 1 in. diameter vertical feeder in the centre, the head of metal being 6 in. The rods obtained with this method were unsound and unsuitable for test purposes. (2) Six separate moulds of the above dimensions with separate feeders were used, with the moulds inclined to the horizontal at a slope of 1 in 9 The castings obtained in this manner were also unsound. It is, however, possible that in the above two cases the casting temperatures were rather low, as these castings were the last to be poured from the crucible. (3) Five patterns, 1 in. diameter by 6 in. long, were moulded in a row with separate feeders ¾ in. diameter with a 6 in. head. These were poured at an inclination of 30 deg. from the vertical, and were more satisfactory. In all cases, however, sand-castings were rather unsound.

STIRRERS, SKIMMERS, &c.

The use of graphite stirrers and skimmers was abandoned at the same time as the use of graphite crucibles, since it was decided to eliminate graphite entirely from contact with the molten metal, except during casting into the mould. Clay stirrers and skimmers were therefore made and used throughout this series of tests.

CASTING TEMPERATURES AND MOULD TEMPERATURES.

With the use of graphite moulds it is possible to use a somewhat lower casting temperature than when iron moulds are used. The melts of the present series were cast to a temperature of about 1,180 deg. C. into moulds preheated to 350 deg. C. Such temperatures were found to produce satisfactory castings. Subsequent examination of the microstructure showed, however, that variations exist, not only from casting to casting, but sometimes in different parts of the same casting. Some variations are no doubt produced by differences in the

* Abstract of a paper read at the meeting of the Institute of Metals, Manchester, on September 12, 1923.

rate of pouring, which it was found impossible to keep constant. Variations of this kind are probably of little importance after the rods have been rolled, but their effect on the properties of the castings themselves is probably considerable, and will be discussed later.

It was found necessary to use an optical pyrometer for the measurement of casting temperatures, and this observation was made through a hole in the furnace lid while the crucible was still in the furnace, the gas being turned off while the temperature was taken. This method was found to give results that agreed fairly closely with those obtained by the use of thermocouples. In early experiments a Hoskins couple immersed directly in the molten metal had been used, but when melts were carried out under a flux it was found that this flux removed the protective coating from the base metal thermocouple wires, and that they were rapidly attacked and dissolved by the molten metal. Their use was therefore abandoned.

Procedure during Melting and Casting.

The chief difficulty in casting was experienced with melts of low oxygen content, and consisted in the evolution of gas while the metal was solidifying in the mould. The copper that was used for making up these alloys originally contained a small percentage of oxygen, reaching, in the case of one sample, 0·016 per cent. In any attempt to remove this by poling or other methods, there appeared to be a danger that the metal might become contaminated by gaseous products resulting from a reduction of the oxygen in the copper, and that this gas might cause unsoundness in the castings. It was therefore decided to melt the copper, if possible, in such a manner that it was not exposed to furnace gases or the air during melting, so that melts should have the same oxygen content as the original cathodes, diminished only by such action as might take place between it and the slag under which it was melted. The following procedure was adopted: 26 lb. of electrolytic copper was cleaned by pickling in 30 per cent. nitric acid, washing, dipping in 10 per cent. potassium hydroxide solution, again washing in running water, and drying carefully. By this method any adhering copper sulphate or other salts and oxide films were removed. A salamander crucible was heated gradually in a furnace and fused borax added to form a fairly deep bath, which was maintained at a temperature a little below the melting point of copper. The prepared copper was then added, a few pieces at a time, so that it was completely submerged beneath the covering. At the same time another salamander crucible *with a clay liner* was heated in another furnace to a temperature of about 1,100 deg. C., and sufficient glass of the composition given on page 351 was added to form a bath in the crucible. Copper that had been preheated under borax was then transferred as rapidly as possible from the preheating crucible and pushed quickly under the molten glass, where the copper melted. This process was continued until all the copper had been treated in this way. By this means it was hoped to obtain a melt of copper which was practically identical in composition with that of the original cathodes, and which had been kept free from all oxidation or other contamination during melting. The borax preheating bath ensured a clean unoxidised surface for the copper before it entered the melting crucible, in which it was completely surrounded by a glass covering in order to protect it from contact with the furnace gases. When all the metal had melted and had reached the required temperature, the crucible was removed from the furnace and a portion of the glass removed, sufficient being left to cover the metal. Clean sand was then stirred in with a fire-clay stirrer, and the residual covering of molten glass thus thickened to enable it the more easily to be held back by a fire-clay skimmer during casting. In the meantime, the graphite moulds, heated to a temperature of 350 deg. C., were removed from the mould-heating furnace. Castings were made in the following order: (1) 1 in. diameter chills. (2) $1\frac{9}{16}$ in. diameter chills. (3) 1 in. diameter chills. The moulds were inclined at an angle of about 30 deg. to the vertical during the operation of casting, and the stream of metal was poured down one side to avoid splashing in the mould.

This procedure was used for melt C35, containing 0·016 per cent. of oxygen. In the case of melt C33, containing 0·015 per cent. of oxygen, no preheating crucible was used and the metal was melted throughout, under a covering of borax, in a crucible without a clay liner. Melts with higher oxygen contents were made under a glass flux, in clay-lined crucibles.

It was observed that on placing the pieces or cathode copper in the molten borax in the preheating furnace, a certain amount of gas was evolved from them during the first few seconds of their immersion. After each piece had been added, three or four bubbles of gas rose to the surface of the borax, where the gas caught fire. This gas was not evolved immediately, and it is thought that it was not due to grease or other combustible material on the surface of the copper, but was more probably gas (possibly hydrogen) given off from the solid copper as it became hot. It was also observed that a reaction took place between the molten borax and the graphite of the crucible, gas being evolved from the bottom and sides of the crucible. It is not known whether such gas can be absorbed to any extent by the solid copper immersed in the borax, but it does not seem probable that such absorption would be very considerable.

The castings obtained in this manner were much sounder than those previously obtained by other methods. In the case of metal low in oxygen some unsoundness was still found, but the metal did not rise appreciably in the moulds. Such rising as did take place merely produced a slight convexity on the surface of the ingot, but there was no visible evolution of gas and the castings themselves were not unduly unsound. Metal containing 0·17 to 0·36 per cent. of oxygen gave perfect castings, which piped considerably in the mould, but were perfectly sound.

The desired oxygen content of the various metals was obtained by the addition of oxygen-rich copper just before the metal was removed from the furnace; a slight loss of oxygen was generally experienced, probably through its removal by the molten flux.

Soundness of $1\frac{9}{16}$ in. Diameter Chill-Cast Billets.

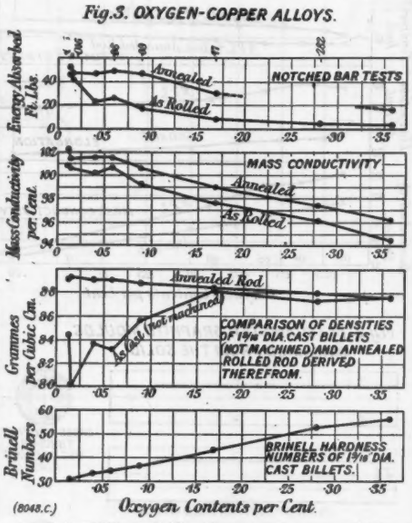
All the billets intended for rolling were examined for soundness when the top end was cut off, and again during the turning of small $3\frac{1}{2}$-in. pieces cut from one billet of each composition for the cold-rolling test, which is described later. In no case was any indication of unsoundness found on the surface of the billet, and such unsoundness as was found in the metal was usually confined to the neighbourhood of the surface down which the metal had been poured. This unsoundness consisted of a number of small holes less than $\frac{1}{4}$ in. in diameter, and frequently only pin-holes, some of which might have been due to shrinkage of the metal, since they occurred at a portion of the billet which was the last to solidify.

Rolling of the Cast Billets.

Rolling tests were carried out in the experimental rolling-mill at the National Physical Laboratory.

Billets, $1\frac{9}{16}$ in. diameter, cast in graphite moulds, were used for these tests; the speed of the rolls was approximately 120 ft. per minute.

Fig. 3. OXYGEN-COPPER ALLOYS.



(*a*) *Cold-Rolling.*—Cold-rolling tests were carried out on the material as cast. In the first experiment "Gothic" rolls were used, but it was found that all the materials tried (containing 0·04per cent. to 0·17 per cent. of oxygen) failed after a few passes by the development of cracks at portions of the section which were not supported by the rolls. The metal did not seem to be sufficiently ductile in the cast state to withstand the severe distortion which takes place when the metal is passed through rolls of "Gothic" section. It is supposed that the slight unsoundness of the billets may have been largely responsible for their ready failure under this very severe test.

It was thought that better results might be obtained if the metal were more adequately supported during its passage through the rolls. Rolls having approximately circular grooves were therefore used, and at the same time the portions of the cast billets intended for this test were turned down to a diameter of $1\frac{1}{3}\frac{1}{2}$ in., and annealed for thirty minutes at 800 deg. C. before rolling. Pieces $3\frac{1}{2}$ in. long, cut from the bottoms of the cast billets, were used for this test. They were passed through the rod rolls until approximately 60 per cent. reduction of the original section was obtained, unless they fractured previously. The number of passes and the conditions generally were kept as constant as possible during the test. Only two billets, containing 0·015 per cent. and 0·016 per cent. of oxygen respectively, withstood a reduction of 55 per cent. to 60 per cent. without splitting. In other cases fracture took place before this amount of reduction had occurred. Oxygen, therefore, does not make copper more ductile in the cold, but has a distinct embrittling effect.

It would appear that, except with very low oxygen contents, no serious amount of cold-rolling can be carried out on the cast material.

(*b*) *Hot-Rolling.*—The surfaces obtained by the use of graphite moulds were so good that no preliminary preparation or machining was necessary prior to hot-rolling. The billets were pre-heated in an electric furnace at 800 deg. C., as it was considered desirable to avoid the use of a gas furnace, owing to the risk of "gassing" the copper, especially in the case of the materials containing much oxygen. The rods were maintained for fifteen minutes at 800 deg. C. and rolled in 16 passes into rods of approximately $\frac{1}{2}$ in. diameter. All materials containing up to 0·36 per cent. of oxygen rolled quite satisfactorily.

(*c*) *Cold-Rolling of Hot-Rolled Bars.*—Portions of the $\frac{1}{2}$ in. diameter rod produced by hot-rolling were annealed at 700 deg. C. for thirty minutes, air-cooled, and cold-rolled in 18 passes to a diameter of approximately $\frac{3}{8}$ in. With the exception of the samples containing 0·28 per cent. and 0·36 per cent. of oxygen respectively, the bars rolled quite satisfactorily. In the case of these two samples, sufficient material was obtained for carrying out further tests on the cold-rolled metal by stopping the cold-rolling at a slightly earlier stage. The behaviour of these two high oxygen coppers was not uniform with regard to the amount of reduction withstood before splitting took place.

Density Tests.

Measurements of density (grammes per cubic centimetre at atmospheric temperature) have been made on sand and chill castings, on rolled bar, and on rolled bar after annealing. In the case of the 1 in. sand and chill castings, the "as rolled" and the annealed rod, the measurements were made on specimens machined to $\frac{1}{2}$ in. diameter. In the case of the $1\frac{9}{16}$ in. diameter chill-cast billets, the measurements were made on the unmachined castings.

Sand-Castings.—The densities of three melts are 8·49, 8·50, and 8·20.

Chill-Castings.—The densities of the 1-in. diameter chill-castings are somewhat irregular, but on the whole the density increases as the oxygen content increases up to a concentration of 0·28 per cent. of oxygen. In the case of the $1\frac{9}{16}$ in. diameter cast billets the highest density is found in the copper containing 0·17 per cent. of oxygen.

Rolled Bar.—The differences in density between "as rolled" and "annealed" specimens are very slight. In the case of metal of low oxygen content, the density of the annealed rod is slightly less than that of the "as rolled" rod, but with the higher oxygen contents the difference is reversed. The density gradually falls in value from approximately 8·91 in the case of copper containing only 0·015 per cent. of oxygen to 8·76 per cent. in the copper containing 0·36 per cent. of oxygen. Over this range of composition the rate of decrease of density with change of composition is constant—that is, the reduction in density is directly proportional to the amount of oxygen present in the alloy.

General Remarks on the Density of the Alloys.

It will appear from the above results that in the case of castings, whether sand or chill, the density is little affected by the proportion of oxygen present in the metal, but is influenced more profoundly by other factors, of which the most important is without doubt the soundness of the casting. Comparison of the density curves for "as cast" billets and annealed rod, given in Fig. 3, shows that those coppers containing less than 0·17 per cent. of oxygen possess a much lower density in the form of chill-castings than in the form of rolled rod, and it is to be supposed that this is due to the unsoundness which was always found to some extent in castings of metal within this range of composition. Moreover, the variable nature of the results obtained is quite in accord with this supposition. The coppers containing 0·17 per cent. and more oxygen possess nearly the same density in the form of chill-castings as in the form of rolled bar, and it may be remarked that in the case of metals within this range of composition the castings produced were remarkably sound, and no blow-holes whatever were found when sections of the ingots were examined. In the case of copper containing 0·36 per cent. of oxygen the densities of cast and rolled material were identical, within the limits of accuracy of the measurements.

The measurement of "density" is a simple and rapid method of determining "soundness," and one that might frequently be adopted with advantage.

(*To be continued.*)

Electrically-Heated Floors.—The electrical heating of the floors of dwelling houses comes, like several other innovations in electrical heating, from Switzerland. The new heating system was introduced last year by the Electra A.G. of Wädenswil, and the heated floor will appeal to people of sedentary habits who have difficulty in keeping their feet warm. Floor heating is best suited to rooms fitted with stone or concrete floors and mosaic flooring; it would be unsuitable for floors made wholly of wood, but is applicable to floors laid with wood planking. The heater coils are placed within iron pipes which are embedded in the flooring, at suitable distances apart, closer near the windows than in the middle portion of the room. When the floor is built up of concrete I beams with thick webs, the pipes are placed in the recesses between the beams and are packed in these recesses with fine gravel. The concrete is covered with a layer of plaster on which the stone slabs or planks are placed. When the floor contains wooden beams, the space between the beams is filled with concrete, when the pipes have been fixed, the wood itself being covered with a layer of gravel lest the structure become too rigid. Between the lower surface of the floor and the concrete containing the heaters an air space is left to prevent radiation downward. That a considerable amount of concrete is wanted for the installation is considered advantageous in so far as the concrete stores the heat, so that the current may chiefly be turned on during hours in which it is hardly wanted for lighting. The coils are drawn into the pipes like cables and are built up in links to retain flexibility. In the *Schweizerische Bauzeitung*, of September 1, in which these devices are described, it is mentioned that the heaters are mostly fitted with two resistance coils, to be coupled in series or in parallel or to be used singly; this is preferable to providing special switches for separate heaters.